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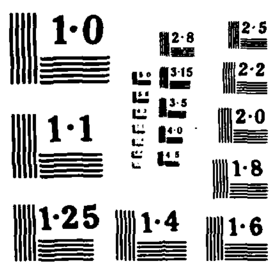
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NORFOLK, VA.

FPO-1-82 (05) SEPTEMBER 1981

Performed for:

OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
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By:

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The major objective of the underwater facility assessments conducted at the U.S. Naval Station in Norfolk, Virginia was to provide a report on the structural condition of five (5) selected piers and one (1) bulkhead. Inspection of the piers was limited by the scope of the project to (Con't)

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visual/tactile evaluation of the reinforced concrete piles supporting Piers 5, 7, 12, 20 and 21. Inspection of Bulkhead CEP-111 was performed in a similar manner by diving engineers. Significant representative defects were photo-documented.

All inspected piers are supported by reinforced concrete piling. The bulkhead is an anchored reinforced concrete sheet pile bulkhead. All pier structures inspected appeared to be in good condition, with only isolated cases of failed of damaged piles. The bulkhead appeared in fair condition with moderate spalling and cracks above the waterline and very limited damage below the waterline.

Damaged piles were typically observed at the exterior portions of the bents; damage was observed only in the upper ten (10) feet of piles. The damage to these piles appeared to have occurred as a result of a direct impact to the piles; generally no significant damage to interior piles or the pier decks was observed.

FOREWORD

The level and methods of inspections performed under this task at the Naval Station, Norfolk, Virginia were based on engineering judgements arrived at through preliminary site reconnaissance, followed by on-site modification of the work effort. This technique allowed the general plan of inspection to be developed and performed by diving engineers with succeeding adjustments made to the general plan during actual in-water work. Due to the many variables of surface and especially underwater inspections, it is felt this method of preparation followed by on-site modification allowed the task to be performed with maximum efficiency and accuracy, resulting in minimal inconvenience to or interference with naval vessels and personnel at the Naval Station, Norfolk. The actual inspection procedures followed at these facilities are suitable for similar facilities. As a rule, details of future inspection procedures should be formulated for each facility according to the extent that conditions warrant.

The presentation of observations and recommendations given in this report is intended to aid the reader to quickly and efficiently evaluate the structures inspected under this task. Furthermore, this report is intended to allow for detailed appraisal of repair requirements.

EXECUTIVE SUMMARY

The objective of the underwater facility assessments conducted at the U.S. Naval Station in Norfolk, Virginia was to provide a report on the structural condition of five (5) selected piers and one (1) bulkhead. Inspection of the piers was limited by the scope of the project to visual/tactile evaluation of the reinforced concrete piles supporting Piers 5, 7, 12, 20 and 21. Inspection of Bulkhead CEP-111 was performed in a similar manner by diving engineers. Significant representative defects were photo-documented.

All inspected piers are supported by reinforced concrete piling. The bulkhead is an anchored reinforced concrete sheet pile bulkhead. All pier structures inspected appeared to be in good condition, with only isolated cases of failed or damaged piles. The bulkhead appeared in fair condition with moderate spalling and cracks above the waterline and very limited damage below the waterline.

Damaged piles were typically observed at the exterior portions of the bents; damage was observed only in the upper ten (10) feet of piles. The damage to these piles appeared to have occurred as a result of a direct impact to the piles; generally no significant damage to interior piles or the pier decks was observed.

The following page is an Executive Summary table which summarizes the assessed condition of the facilities and repair recommendations.

EXECUTIVE SUMMARY TABLE

FACILITY	YEAR BUILT	LENGTH X WIDTH (# OF PILES)	ASSESSED CONDITION	RECOMMENDATIONS/ REPAIR COSTS/ EXPECTED LIFE (WITH REPAIR)
Pier 5	1942	1354' X 104' (1725)	Overall good; 1.3% exhibit damage (23 piles); 1 pile in failed condition	Repair Failed & Damaged Piles/ $2,450 25 Years
Pier 7	1931	1352' X 104' (1960)	Overall good; 6.0% exhibit damage (118 piles); 2 piles in failed condition	Repair Failed & Damaged Piles/ $8,575 20 Years
Pier 12	1959	1306' X 150' (2250)	Overall good; 4.5% exhibit damage (102 piles); 0.2% failed condition (4 piles)	Repair Failed & Damaged Piles/ $11,150 30 Years
Pier 20	1954	1451' X 50' (1056)	Overall good; 6.3% exhibit damage (67 piles); 1.0% failed condition (11 piles)	Repair Failed & Damaged Piles/ $14,650 30 Years
Pier 21	1944	1405' X 50' (990)	Overall good 9.4% exhibit damage (93 piles); 2.0% failed condition (20 piles)	Repair Failed & Damaged Piles/ $45,525 20 Years
Bulkhead (CEP-111)		1183'/NA N/A	Fair; Leaking Sheet Pile Joints; Impact Damage & Deterioration of Concrete Above Water	Seal Sheet Pile Joints & Repair Above Water Damage $40,000 15 Years

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

LIST OF FIGURES

LIST OF PHOTOGRAPHS

SECTION 1.0 - INTRODUCTION

This report is a product of the underwater inspection program conducted by the Ocean Engineering and Construction Project Office (FPO-1), Chesapeake Division, Naval Facilities Engineering Command (NAVFACENGCOM) under NAVFAC's Specialized Inspection Program.

Mandated under Contract No. N62477-81-C-0286, this program provides for task oriented engineering services in support of the inspection, analysis and design, and monitoring of repairs for the submerged portions of selected Navy waterfront facilities. All services required to produce this report were provided by Arthur V. Strock & Associates, Inc. of Deerfield Beach, Florida, under Task No. 1 of this underwater inspection program.

The labor and expenses required to carry out underwater facility inspections is dependent on a significant number of factors. The size and number of structural members to be inspected is important. However, the structural condition of such structural members has as much influence on the total degree of accuracy and efficiency with which the task can be performed. As the size and number of structural members increases so does the required effort to carry out an inspection. Furthermore, the poorer the structural conditon, the greater the number of irregularities which must be documented for a thorough inspection. To effectively assess the condition of any structure, the engineer must consider possible failure loadings and how failure can be evidenced in the structure. To provide a comprehensive inspection of a structure underwater, water clarity, ambient light levels, and degree of biofouling must be considered in advance of the inspection. Mechanical aids such as underwater lights, clearwater bags, wide-angle lenses, and scrapers, can be used to aid in visual assessment of underwater structures. Other factors such as water temperature, pollutants, harmful sealife, in addition to waves, currents, and tidal action must all be considered.

The inspections at Naval Station, Norfolk, were performed following consideration of all these factors using SCUBA life-support systems. The ability to utilize SCUBA at this facility greatly increased the efficiency with which this specific inspection was performed. Details of field procedures followed under this task are given in Section 3 of this report.

1.1 Task Description

This task entails engineering services necessary to perform an underwater inspection and subsequent assessment of the structural members supporting five (5) piers and one (1) bulkhead at the Naval Station, Norfolk, Virginia. Structures inspected are Piers 5, 7, 12, 20, 21 and Bulkhead CEP-111.

1.2 Report Content

In this report inspection procedures, results of inspection, and analysis of the findings are provided. Each facility inspected at the Naval Station is described as to its location, function, construction, inspection condition, and condition assessment. Recommendations for each facility are also provided. Structural assessment calculations and cost estimate breakdowns are given in the Appendix. Also, as supplementary information, a brief description of the Naval Station is included to illustrate its location, mission, facilities, hydrographic and topographic features and other pertinent data. This supplementary information was obtained from the Master Plan for the Naval Station.

SECTION 2.0 - ACTIVITY DESCRIPTION

The purpose of this section is to provide a general description of the Naval Station in Norfolk, Virginia. The section includes brief descriptions of the Naval Stations' location, mission, existing facilities, climatological and meteorological data, and hydrographic data. The information is provided to aid in identification of the facility and to support all considerations necessary to accurately assess the condition of facilities inspected under this task.

2.1 Location of Activity

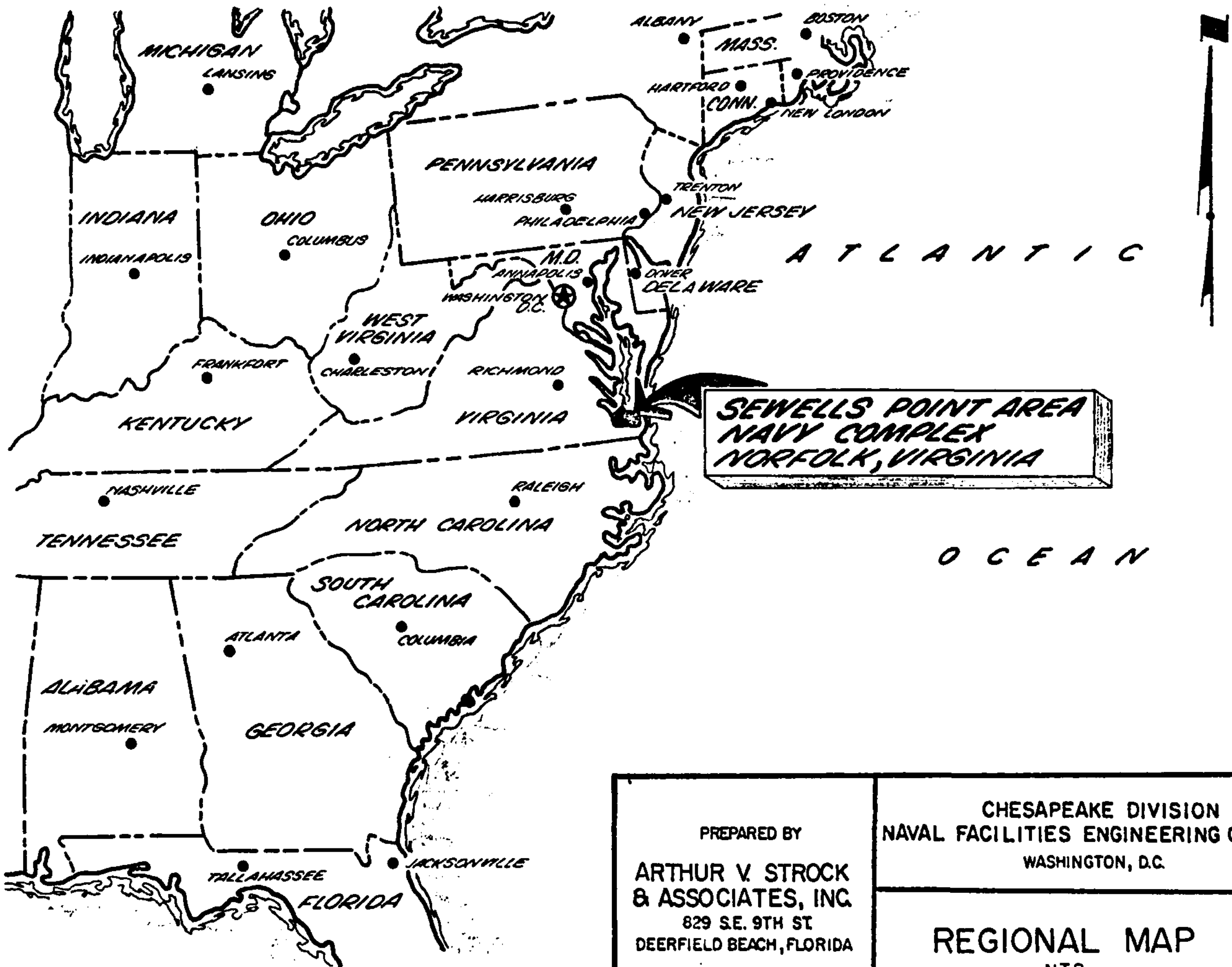
Located at latitude 36 degrees 55 minutes north and longitude 76 degrees 22 minutes west, the Norfolk Naval Station piers form one part of the much larger Sewells Point Area Navy Complex (Figures 1, 2 & 3). "The Sewells Point Complex is situated in the worlds' largest natural harbor, Hampton Roads. This strategic location enjoys access to the Atlantic Ocean through Chesapeake Bay, providing a natural protective site for its main function of home porting the majority of current active ships in the Atlantic fleet" (Reference 1).

2.2 Mission of Facility

"Naval Station, Norfolk is the key host activity in Sewells Point, with the assigned mission of providing logistic support for the Operating Forces of the Navy, and for dependent activities in other commands as assigned. The specific importance of the Naval Station to the Sewells Point Complex is reflected in its assigned functions and tasks. Among the most significant is to provide and coordinate all activities associated with the berthing of, and services to, home-ported and transient ships (Reference 2).

2.3 Climatological and Meteorological Data

"The area's climate is moderate, with the winters relatively mild. Warm summers are frequently tempered by northeasterly breezes from the Atlantic Ocean. The mean minimum temperature for this region is 50.5 degrees F. The mean maximum temperature is 68 degrees F, with monthly averages varying from 41.2 degrees F in January to 78.6 degrees F in July. Prolonged cold waves seldom penetrate this area and the daily minimum temperature rarely goes below 20 degrees F. The average frost free period covers 239 days from March 23 to November 18th. Precipitation is well distributed throughout the year. The annual average is 46.25 inches, with a high of 6.5 inches occurring during July. Snowfall averages 9.1 inches per year occurring chiefly during December and January. Major melting occurs within 24 hours after the snowfall has ceased. Frost penetration for design use is calculated to be 12 inches. Averages of temperature,



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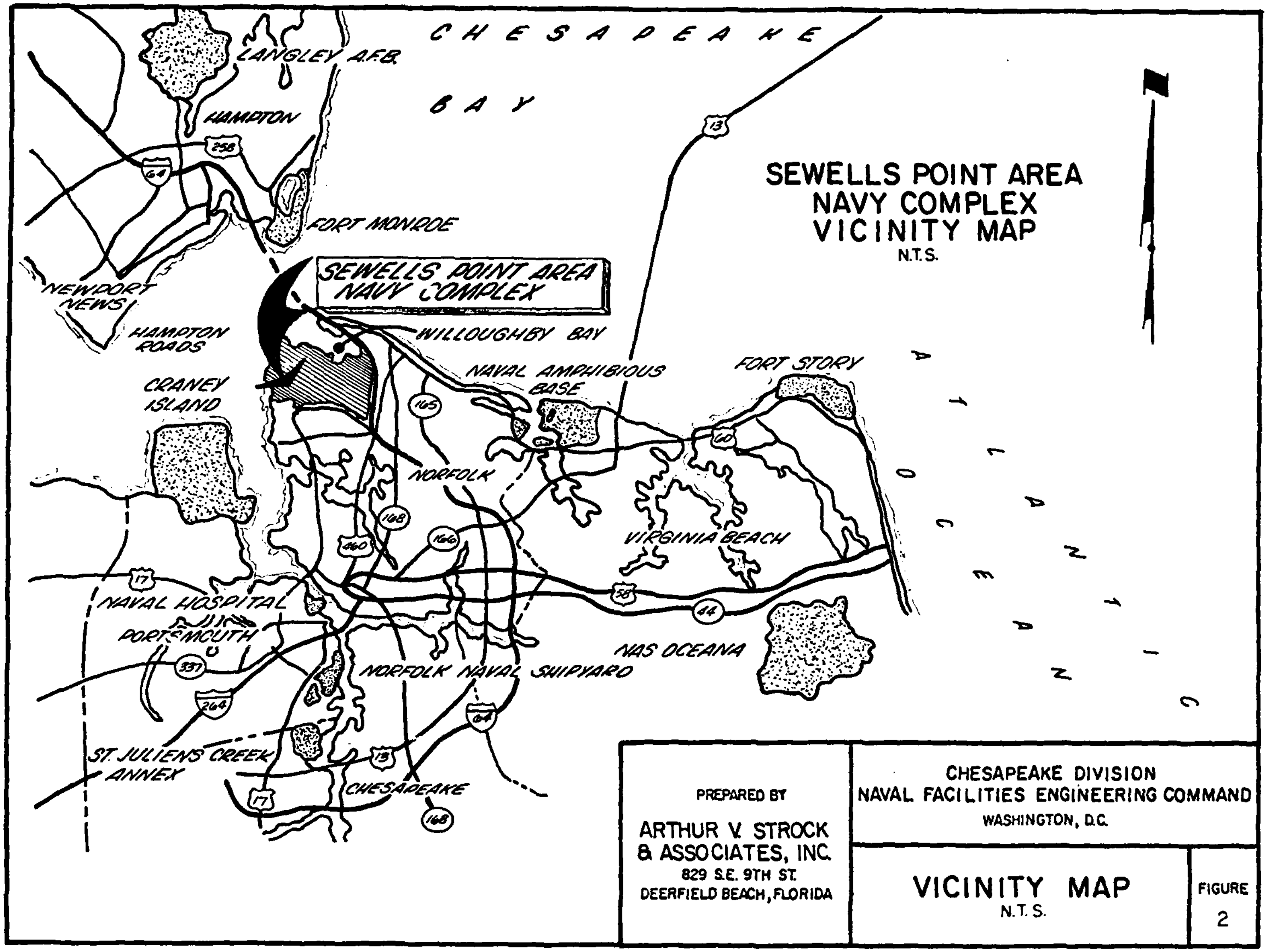
	REGIONAL MAP N.T.S.	FIGURE 1



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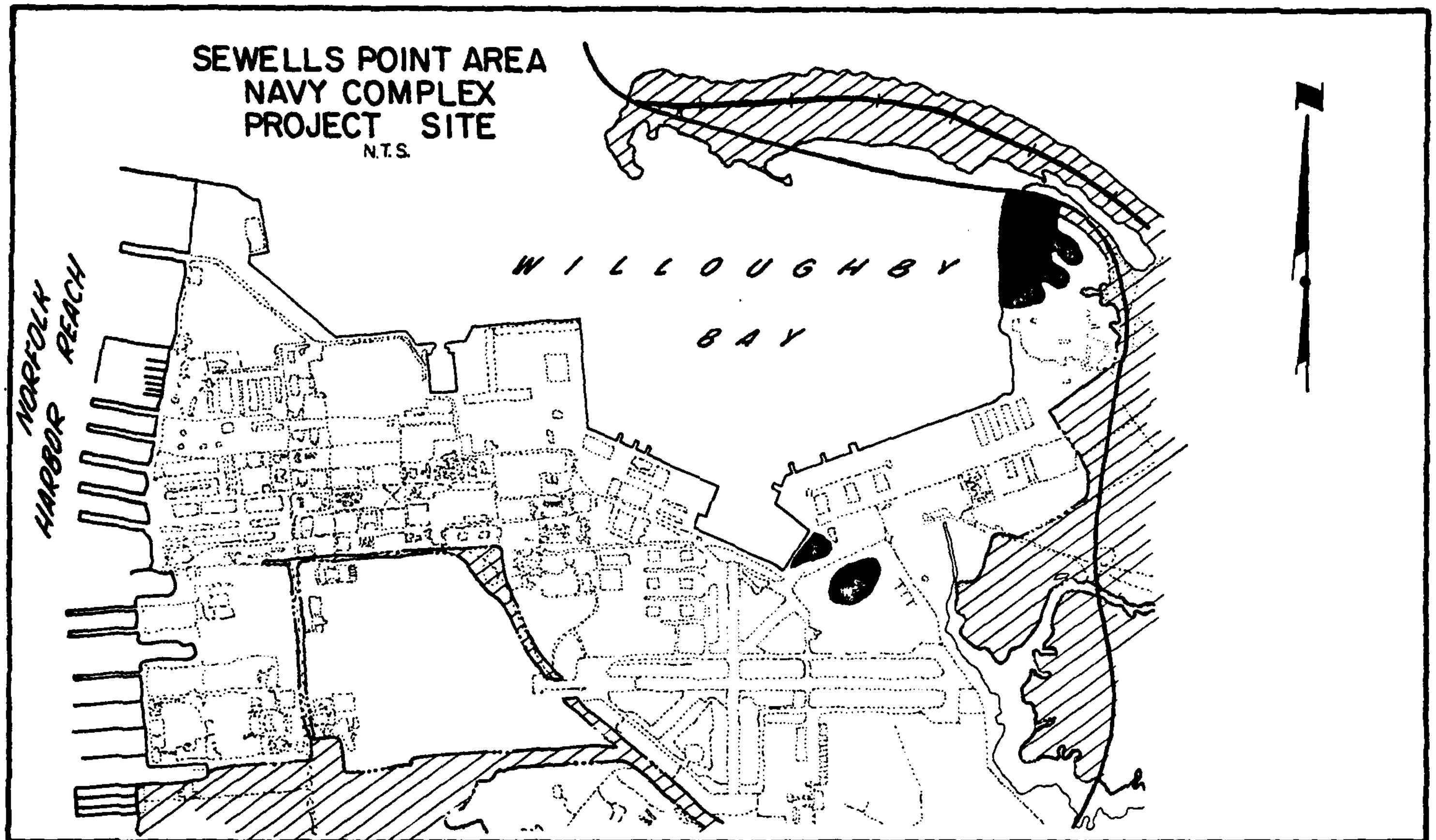
VICINITY MAP
N.T.S.

FIGURE 2



LEGEND

OFF BASE

FLOOD PLAIN

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PROJECT SITE

FIGURE 3

relative humidity and precipitation are graphically shown on Figure 4. The wind velocity is less than 12 knots 80 percent of the time and seldom exceeds 20 knots. The prevailing direction is generally southwest in the early winter, spring and early summer, with the highest velocity usually occurring during the hours of darkness. However, northeasterly winds prevail about 25 percent of the time, with highest velocity occurring during the daylight hours. Data on wind velocity and direction is provided by Figure 5. The geographical position of the Complex with respect to principal storm tracks is especially favorable, being south of the average paths of the strorms originating in the higher latitude and north of the usual track of hurricanes and other tropical storms. Winds of hurricane force have occurred on an average of once every seven years. The mean range of tide in Hampton Roads is 2.5 feet. The average velocities in mid-channel at strength of flood or ebb tide is about 1.25 knots; however, currents are greatly influenced by the winds" (Reference 1).

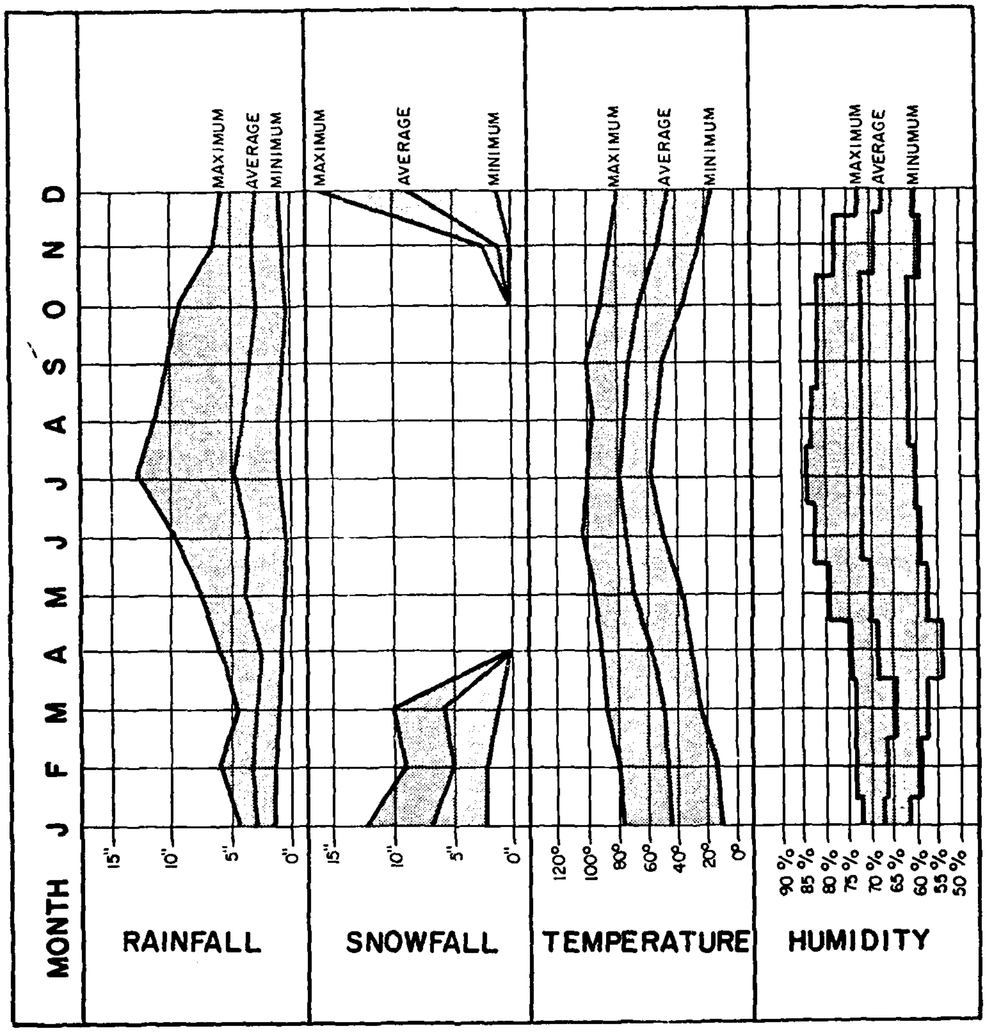
2.4 Hydrology

"The two principal bodies of water include the salt water mass of Hampton Road, Willoughby Bay (Eastern Boundary), the Elizabeth River (Western Boundary), and Mason's Creek, which is basically fresh water made slightly blackish by tidal salt water drainage. The key concern of this environmental feature is the collaborative impact of water with winds and hurricanes. Bulkhead stability and soil erosion are constant and expensive maintenance items" (Reference 1).

2.5 References

1. Sewells Point Area Navy Complex

2. Master Plan, Naval Station Norfolk



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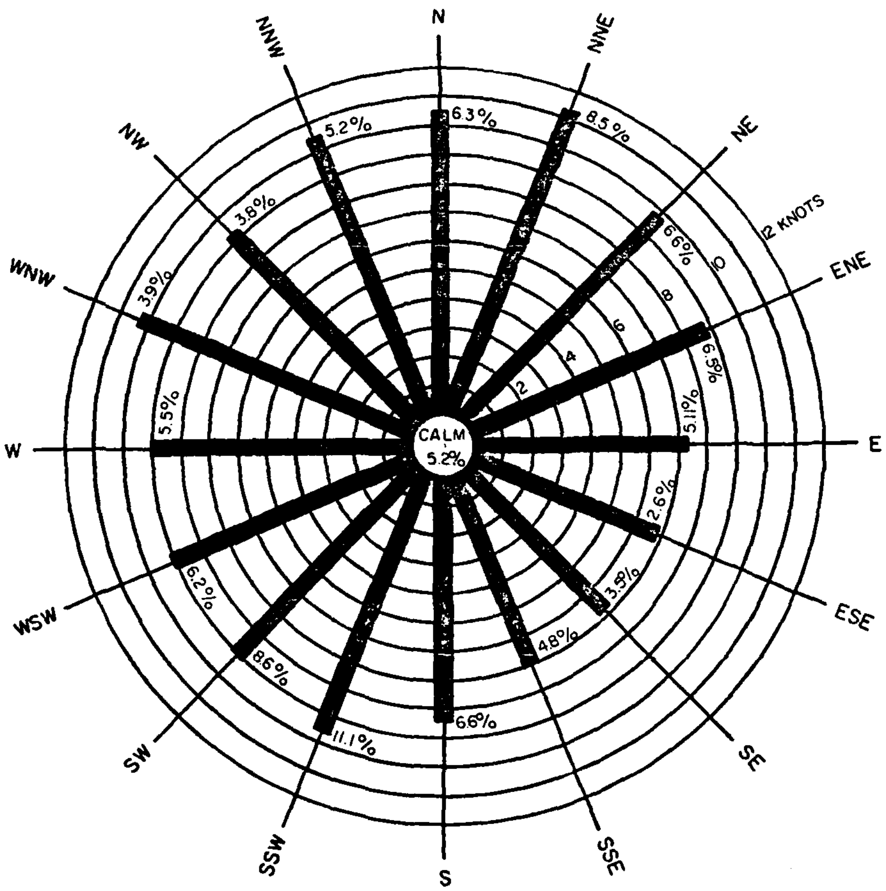
		CLIMATOLOGY	FIGURE 4



SEWELLS POINT AREA
NAVY COMPLEX

SCALE: 3/16" = 1 KNOT

FROM MASTER PLAN NAVAL STATION NORFOLK NORFOLK, VIRGINIA ATLANTIC DIVISION NAVAL FACILITIES ENGINEERING COMMAND	PREPARED BY ARTHUR V. STROCK & ASSOCIATES, INC. 829 S.E. 9TH ST. DEERFIELD BEACH, FLORIDA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C. WIND ROSE	FIGURE 5

SECTION 3.0 - INSPECTION PROCEDURE

3.1 Level of Inspection

During the period September 16 - September 23, 1981, a team of diving engineers performed a Level I and Level II underwater inspection of selected piers and a bulkhead at the Naval Station in Norfolk, Virginia. Level I "swim-by" inspections were made on all of the piling supporting the designated piers. The more thorough Level II inspection entailed the divers descending and ascending on an individual pile, while making note of any damage to that pile. The pile face was cleaned as necessary to assess the condition of the pile. Photographs were taken to illustrate specific and typical conditions.

3.2 Inspection Procedure

The combination of water conditions, pier construction and required levels of inspection allowed the diving engineers to perform both the pier and bulkhead inspections utilizing SCUBA diving equipment. The scope of work included Level I inspection of almost 8,000 reinforced concrete piles, supporting Piers 5, 7, 12, 20 and 21; and approximately 1,150 feet of concrete bulkhead designated as Bulkhead CEP-111.

A Level I swim-by inspection by the diving engineers was performed on all facilities under this task. On a Level I inspection of the piling, diving engineers carried data recording slates as they swam along the surface. The diving team swam together between two (2) pier bents as each member of the team inspected a bent. Conditions of the piles were recorded at the immediate time of inspection by the diving engineer. Level II inspection entailed a close inspection of the piles from the surface to the mudline. Piles were cleaned as necessary to facilitate inspection. Level II inspection observations were typically recorded at the surface due to poor visibility under water.
Figure 6 is a reduced copy of the data recording slate.

Figure 7 illustrates the paths followed by the divers. The data recording sheets allowed the diving engineer to record the following observations at each pile:

1. The amount of marine growth on the piles.

2. The condition of the concrete, i.e. whether it was cracked, spalled or failed.

LEVEL I

NAVAL STATION AT NORFOLK, VIRGINIA

PIER-PILING INSPECTION

PIER:______ BENT:______ INSPECTOR:______

2

1

0

-1

-2

-3

Marine Growth

less than 1" of growth	1
greater than 1" of growth	2

Concrete

Good condition no apparent problems	0
Hairline cracks	1
Failure cracks	2
Spalled concrete on surf	3
Deeply spalled concrete	4
Failed pile (no apparent bearing capacity)	5

Steel

Minor

Major

Corrod

Corrod

LEVEL II

0 5 10 15 20 25 30 35 40

ARTH

PIER:______ BENT:______ INSPECTOR:______________ TIME:______ DATE:______

ete

condition no apparent problems	0
ine cracks	1
re cracks	2
led concrete on surf	3
y spalled concrete	4
d pile (no apparent bearing capacity)	5

Steel

Minor rust stains	1
Major rust stains	2
Corroded steel (section not exposed)	3
Corroded steel (section exposed)	4

20	25	30	35	40	45	50	55	60

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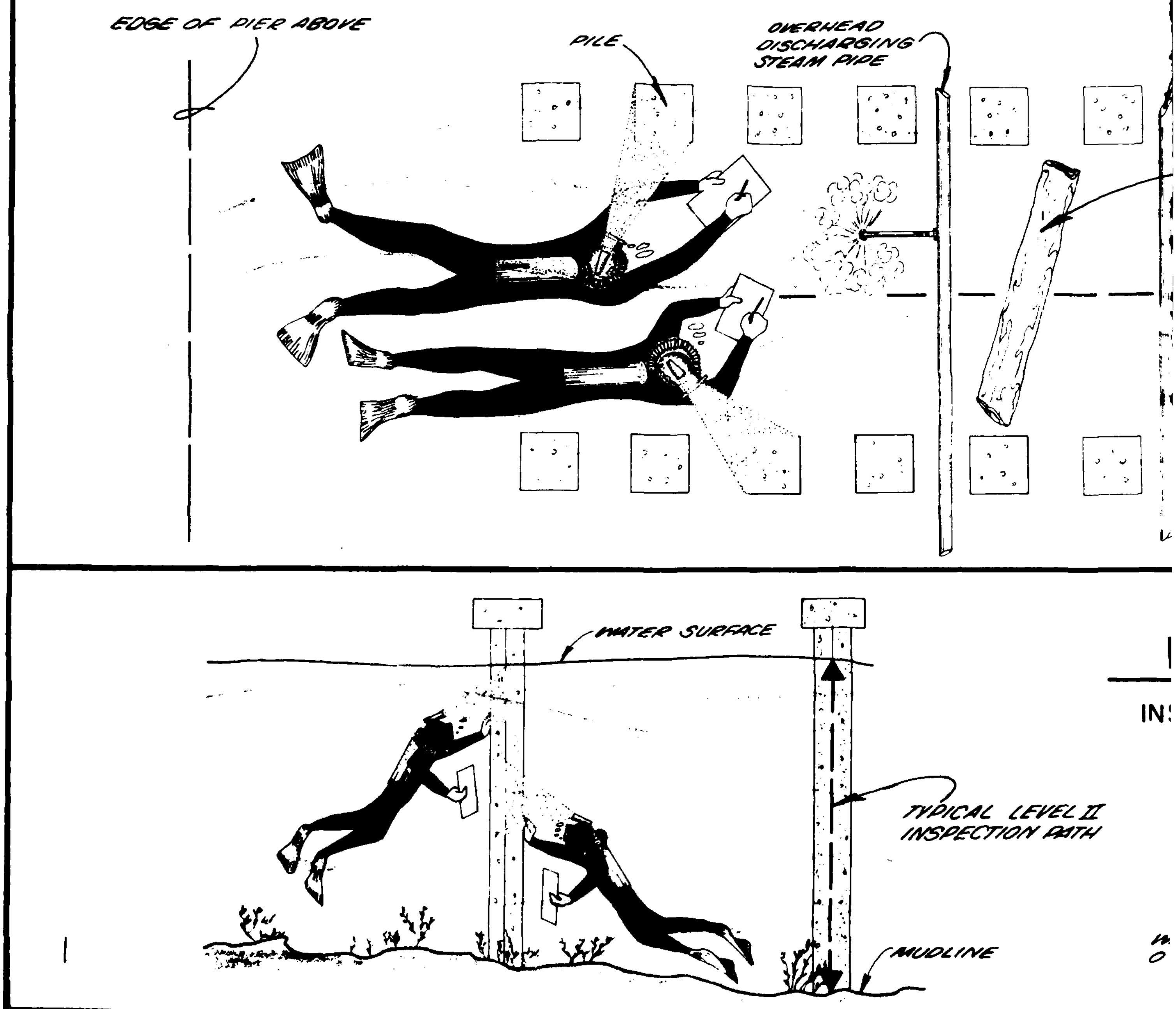
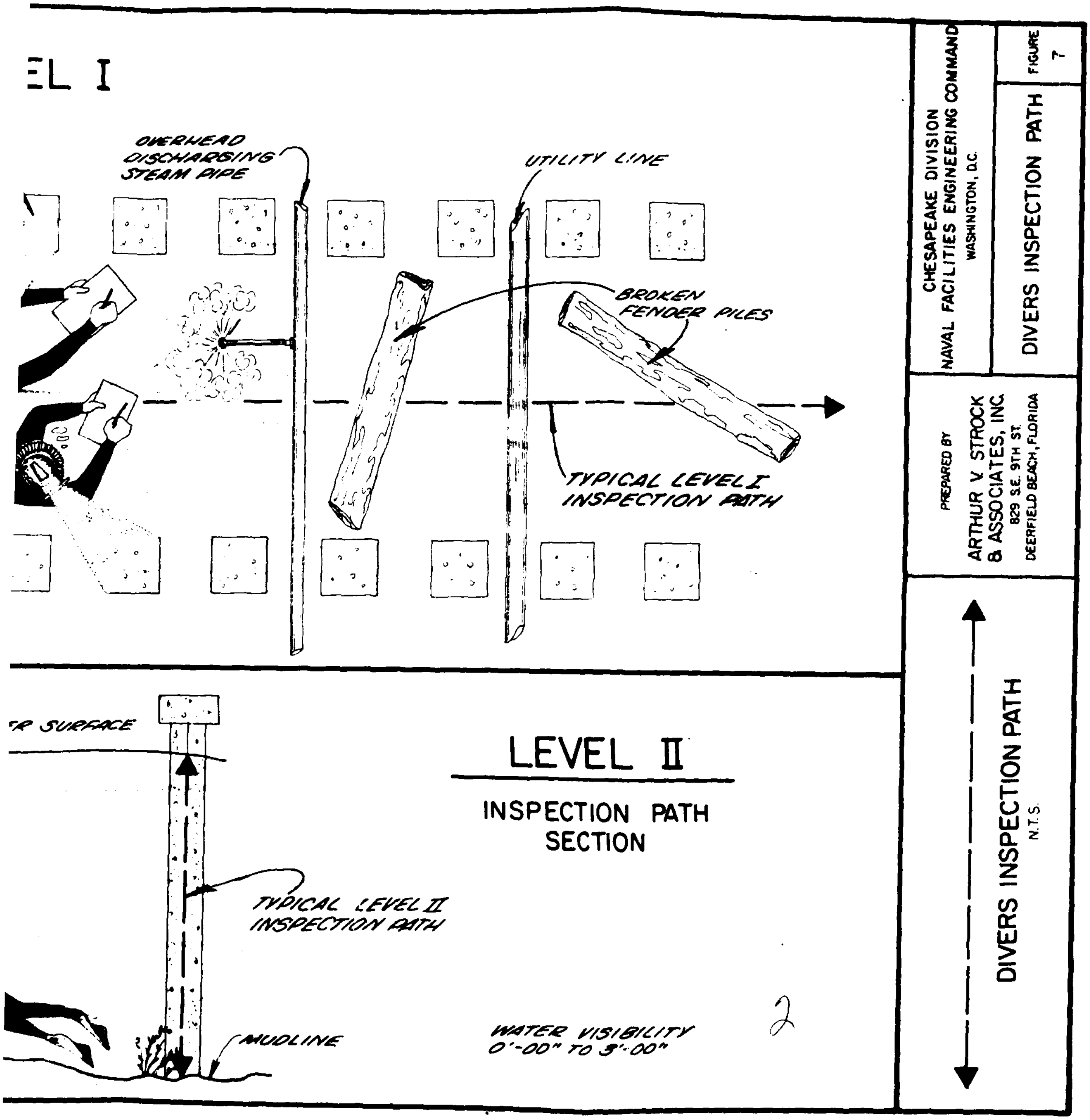
2

LEVEL I


EDGE OF PIER ABOVE
PILE
OVERHEAD DISCHARGING STEAM PIPE
WATER SURFACE
TYPICAL LEVEL II INSPECTION PATH
MUDLINE
INS


EL I
OVERHEAD DISCHARGING STEAM PIPE
UTILITY LINE
BROKEN FENDER PILES
TYPICAL LEVEL I INSPECTION PATH
R SURFACE
LEVEL II
INSPECTION PATH SECTION
TYPICAL LEVEL II INSPECTION PATH
MUDLINE
WATER VISIBILITY 0'-00" TO 3'-00"
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.
DIVERS INSPECTION PATH
FIGURE 7
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DIVERS INSPECTION PATH
N.T.S.

3. The amount of rust or exposed steel showing on the pile.

4. Any other comments the engineer felt should be recorded concerning his observations.

The above conditions were coded as shown on the data recording slate (see Figure 6 and Table 1 below). Consider an example: a pile was observed to have less than one (1) inch of marine growth, hairline cracks and minor rust stains; this pile was coded as "G1, C1, S1." All steel and concrete codes describe defects except for "C0".

TABLE 1
CONDITION CODES

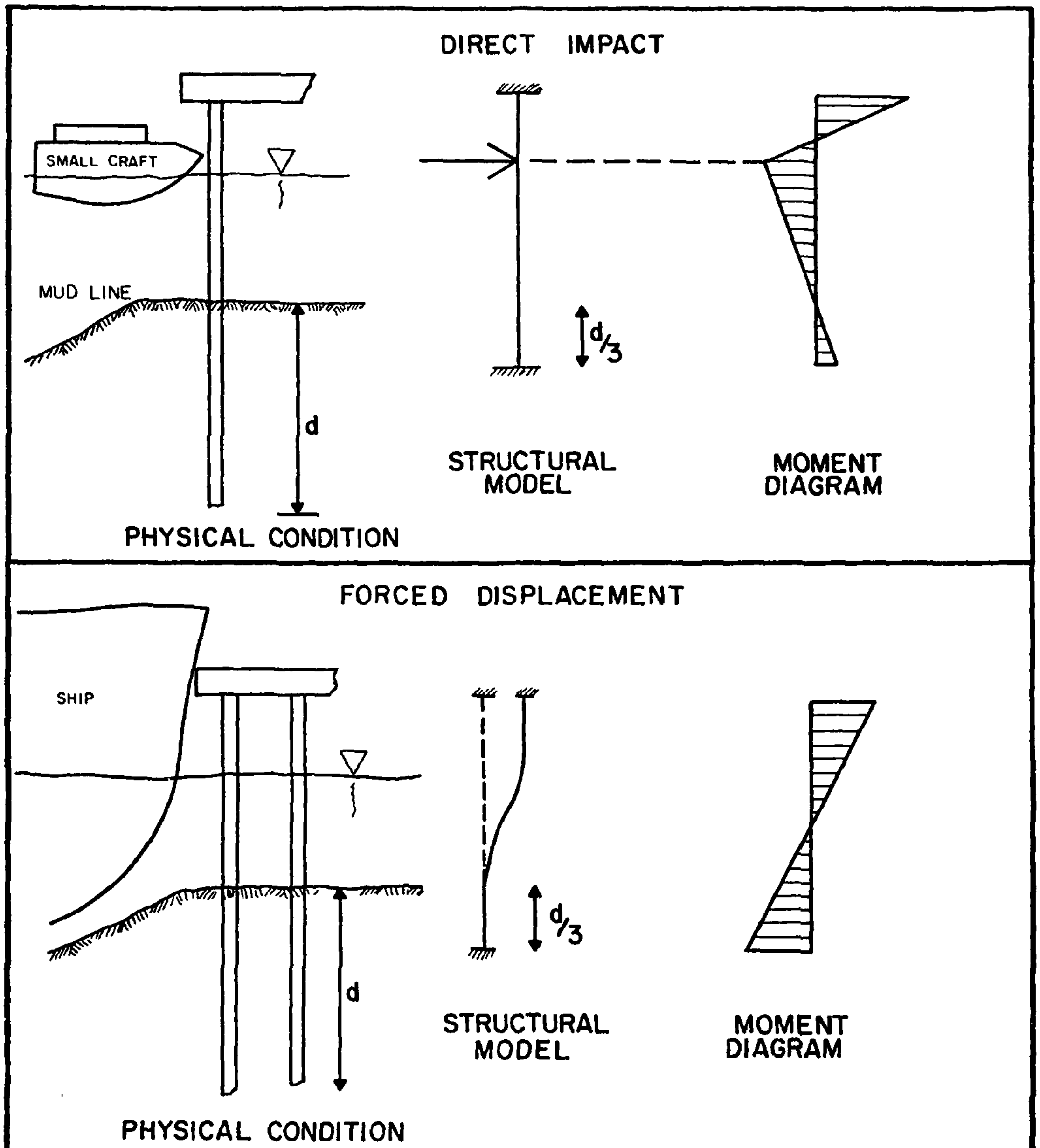
Element	Code	Description
Marine Growth	G1	Less than 1" of growth
	G2	Greater than 1" of growth
Concrete	C0	Good condition, no apparent problems
	C1	Hairline cracks
	C2	Failure cracks
	C3	Spalled concrete on surface
	C4	Deeply spalled concrete
	C5	Failed pile (no apparent bearing capacity)
Steel	S1	Minor rust stains
	S2	Major rust stains
	S3	Corroded steel (section not exposed)
	S4	Corroded steel (section exposed)

In order to prepare for each inspection, the bents on each pier were numbered, starting at the bulkhead and proceeding to the outboard end of the pier. Piles were numbered from south to north. As the diving engineers proceeded with their inspection, surface personnel would verify the bent number with the divers. Each of two (2) teams of diving engineers spent two (2) to three (3) hours in the water performing both Level I and Level II inspections during each day on the site. As previously described, the Level I inspections were performed by engineers swimming horizontally and recording pile conditions. Level II inspections were performed by both diving engineers descending on a pile to the mudline. Due to the low water visibility, the diving engineers would remain in direct physical contact as each

descended on one face of the pile. If at some point, the diving engineers deemed it necessary to remove marine growth for closer inspection of the pile, the divers would halt the descent and clean an area of the piling face before preceeding with the rest of the Level II inspection. This procedure of cleaning an area of piling was severely hampered at times by the large quantities of silt that would be disturbed in the cleaning process and, as a result, reduced the diving engineers visibility to zero (0).

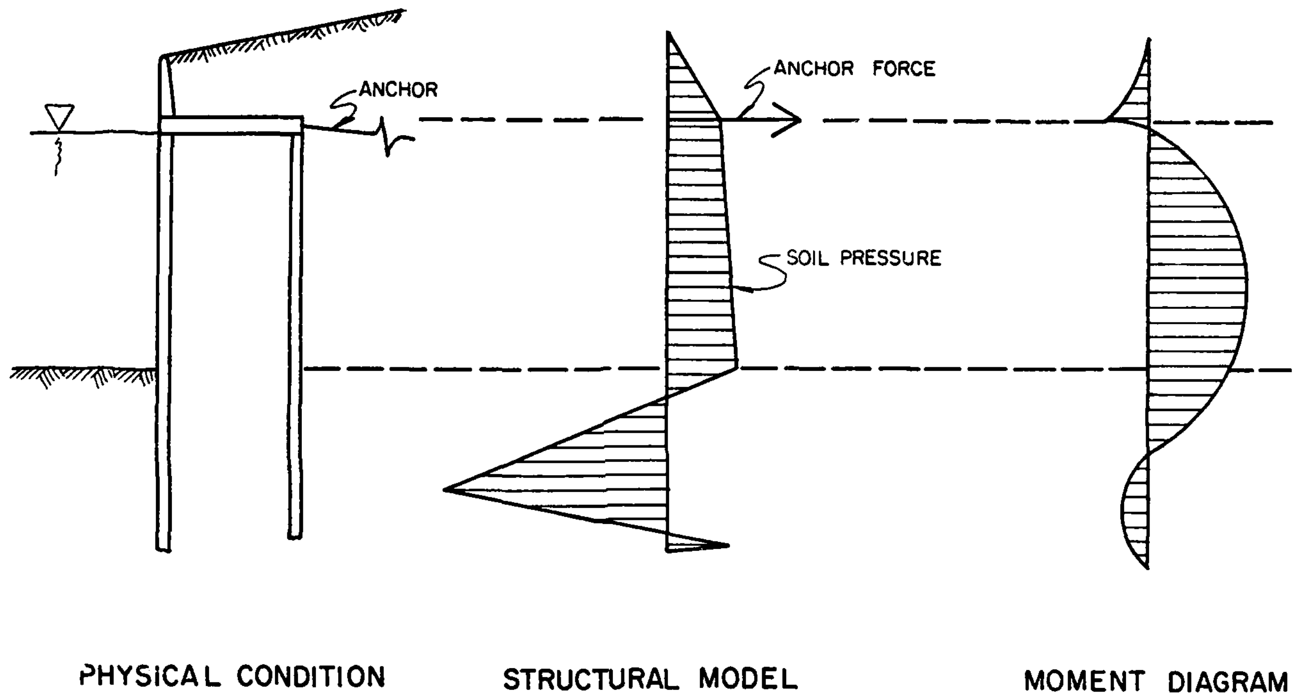
Initially, both Level I and Level II inspections were performed by each diving engineer inspection team, as they progressed from bent to bent. After the second day of inspections, a more efficient manner of inspection was soon devised by the diving engineers. This modified inspection procedure required the in-water diving engineers to perform only one (1) level of inspection at a time. One (1) team of diving engineers would perform Level I inspections only; the other team would perform Level II inspections only. This simple modification allowed the inspection to proceed more rapidly since it eliminated the necessity for the diving engineers to transform from horizontal swimming (as required for Level I inspections) to vertical descent and ascent (as required on Level II inspections). According to this procedure, one (1) team of diving engineers would enter the water, prepared to swim on the surface carrying data recording slates. Utilizing the data obtained from their observations, the second team of diving engineers would enter the water, prepared to carry out vertical inspections on pilings, either chosen from the results of the preceeding Level I inspection or chosen as a representative pile. The diving engineers performing Level II inspections also photo-documented representative surface and underwater conditions.

The diving engineers performed a concentrated inspection of piles at the cap, at the mudline and at the midsection of the piles. This concentrated effort was made in these areas as they are expected to demonstrate damage due to overloading of the piles. Figure 8 shows the expected failure modes for typical pier piles in terms of the physical condition, structural model and moment diagram. The most probable cause of pile failure is direct impact and a forced displacement at the cap due to a mooring force impact at the cap. In both cases, the maximum moment exists near the cap or near the mudline. For both modes of probable pile failure, exterior piles are most likely to fail due to their proximity to applied loads. Figure 9 shows the typical physical conditions, structural model and moment diagram for an anchored bulkhead with a fixed earth support. Pile failure is most likely to occur as a result of a moment failure. Furthermore, the splash zone and tidal zone were closely inspected as these areas are most susceptible to reinforcement steel corrosion and concrete deterioration due to exposure to the elements. Appendix A, pages A-1 through A-4, contains further structural analysis.



REFERENCE CHELLIS, R.D. "PILE FOUNDATIONS" 2nd EDITION NEW YORK McGRAW-HILL	PREPARED BY ARTHUR V. STROCK & ASSOCIATES, INC. 829 S.E. 9TH ST. DEERFIELD BEACH, FLORIDA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C. PIER PILE FAILURE MODES	FIGURE 8

ANCHORED BULKHEAD



REFERENCE RICHART, F.E. JR. "ANCHORED BULKHEAD DESIGN BY NUMERICAL METHOD" TECHNICAL PAPER 189 UNIVERSITY OF FLORIDA AUG., 1960	PREPARED BY ARTHUR V. STROCK & ASSOCIATES, INC. 829 S.E. 9TH ST. DEERFIELD BEACH, FLORIDA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C. ANCHORED BULKHEAD & FIXED EARTH SUPPORTS — FIGURE 9

3.3 Inspection Equipment

The following equipment was utilized by diving engineers during pier and bulkhead inspections:

1. Standard scuba diving equipment;
2. Full 3/16" wetsuits for thermal and abrasion protection;
3. Head-mounted dive lights;
4. Buoyancy compensators (utilized to adjust the divers in-water buoyancy, so that he may descend, ascend or float on the surface);
5. Nikonos-3 underwater camera with Toshiba strobe;
6. Subawider wide-angle underwater lens attachment (used for taking close-up photographs in turbid water);
7. Assorted scrapers, chipping hammers, calipers; and,
8. Underwater data recording slates.

SECTION 4.0 - FACILITIES INSPECTED

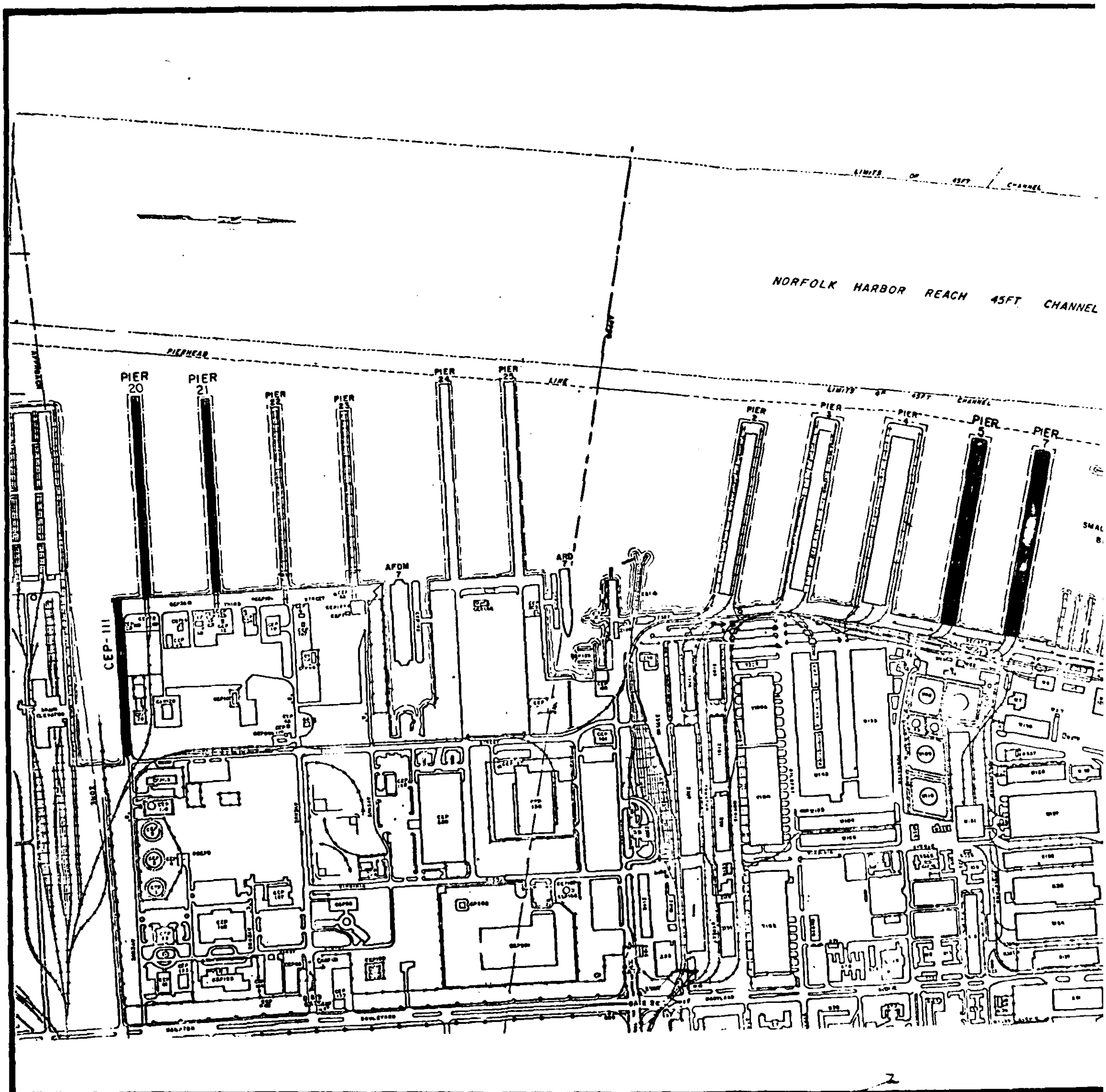
4.1 Designated Facilities Inspected

The inspections performed at the Norfolk Naval Station revealed that all structures inspected are in overall good condition. No more than eight (8) percent of the total piles of any one (1) pier showed defects. In addition, no pier exhibited more than two (2) percent of its total pilings to be in a failed condition (e.g., heavily spalled or broken piles, such that the pile appeared to have limited or no apparent bearing capacity). The 1,183 feet of bulkhead inspected was also found to be in good condition below the water line, and in fair condition above the water line. Representative photographs were taken of typical conditions found above and below the water surface. These photographs appear with the detailed description of each structure's condition.

The marine growth observed on all structures was generally limited to less than one (1) inch of soft growth - mainly tunicates and hydroids appearing in the tidal zone on the piles. Two (2) to three (3) inches of soft growth interspersed with barnicles (10 to 20 organisms per square foot), and oysters (one (1) to three (3) organisms per square foot) were found below the tidal zone. None of the marine growth was solid or thick enough to hamper cleaning or inspection of the piles.

Of all structural damage observed by inspectors, the highest percentage occurred to the exterior piles which are most susceptible to impact from ships and other floating objects.

In the remaining portion of this section, each facility inspected at Naval Station, Norfolk is referenced separately. A description of its construction, specific observed conditions, and assessment of these conditions and recommendations for repairs are included for each facility inspected. Further details of the inspection findings, structural analysis (basis of assessment), and cost estimate breakdown are contained in the Appendix. Figure 10 shows the location of all inspected facilities on base.



NORFOLK HARBOR REACH 45FT CHANNEL
LIMITS OF 45FT CHANNEL
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CEP-111
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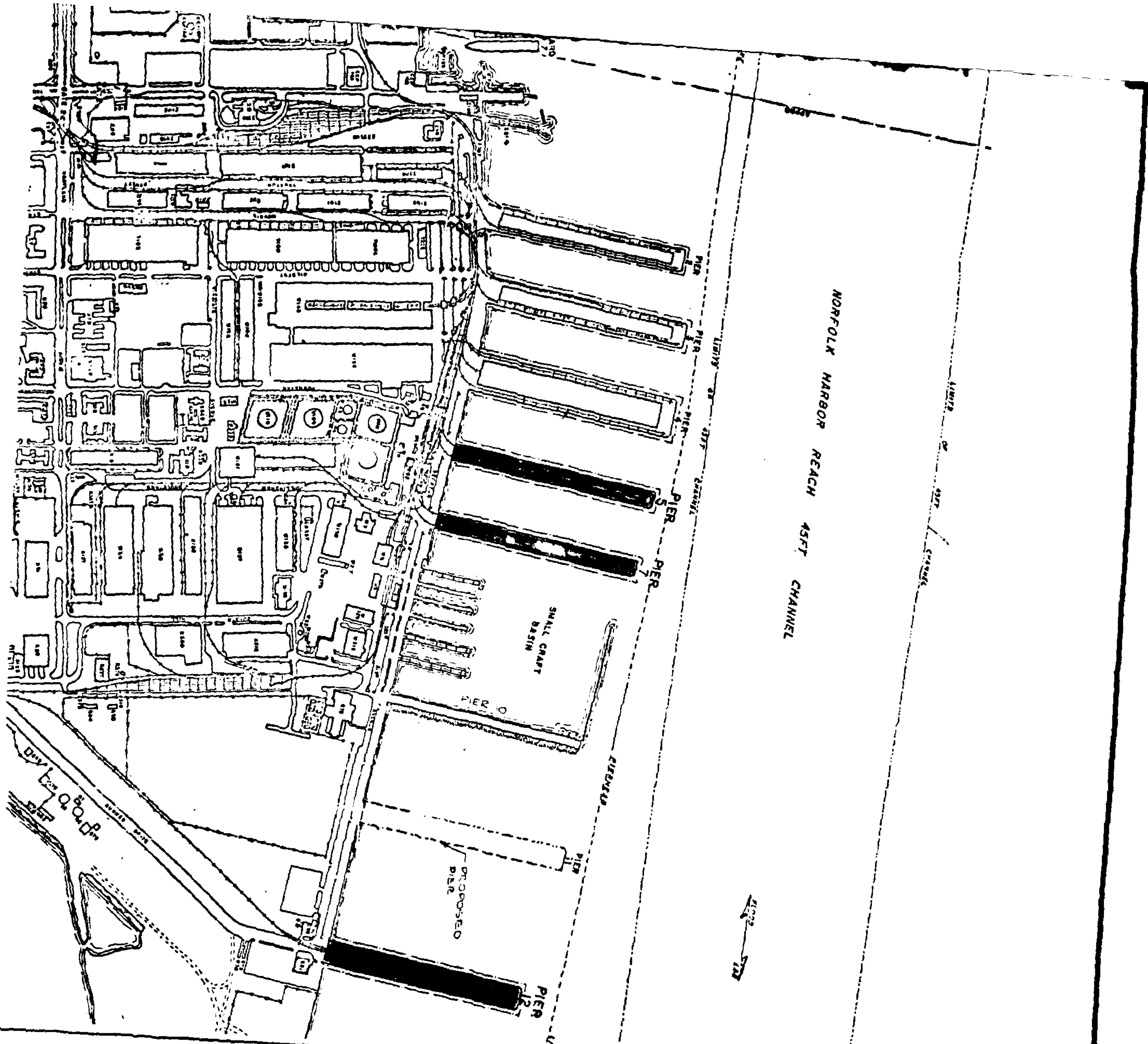
PIER 3
PIER 4
PIER 5
PIER 7



INSPECTED FACILITIES ARE SHADED

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FACILITY LOCATIONS ON BASE

FIGURE 10

4.2 Pier Number 5

4.2.1 Description

Pier 5 is constructed of reinforced concrete and is 1,054 feet long and 104 feet wide. The pier is located between Piers 4 and 7 to the south and north respectively. Figure 10 shows the location of Pier 5 on base. The pier was constructed in 1942. A total of 1,725 reinforced concrete piles support the deck of this pier. The pier has 115 bents, each bent has 13 vertical piles and two (2) batter piles, for a total of 15 piles per bent. Figure 11 shows a typical bent for Pier 5. All piles were inspected on a Level I basis and 91 piles inspected according to Level II requirements. During Level I and Level II inspections, several Naval vessels were berthed at Pier 5. All ships were informed of the presence of divers in the water and took measures to assure the safety of these divers. Performance of Level I inspections was hampered by an unusually heavy concentration of both diesel fuel and sludge present on the water surface along the south inboard portion of the pier.

4.2.2 Observed Inspection Conditions

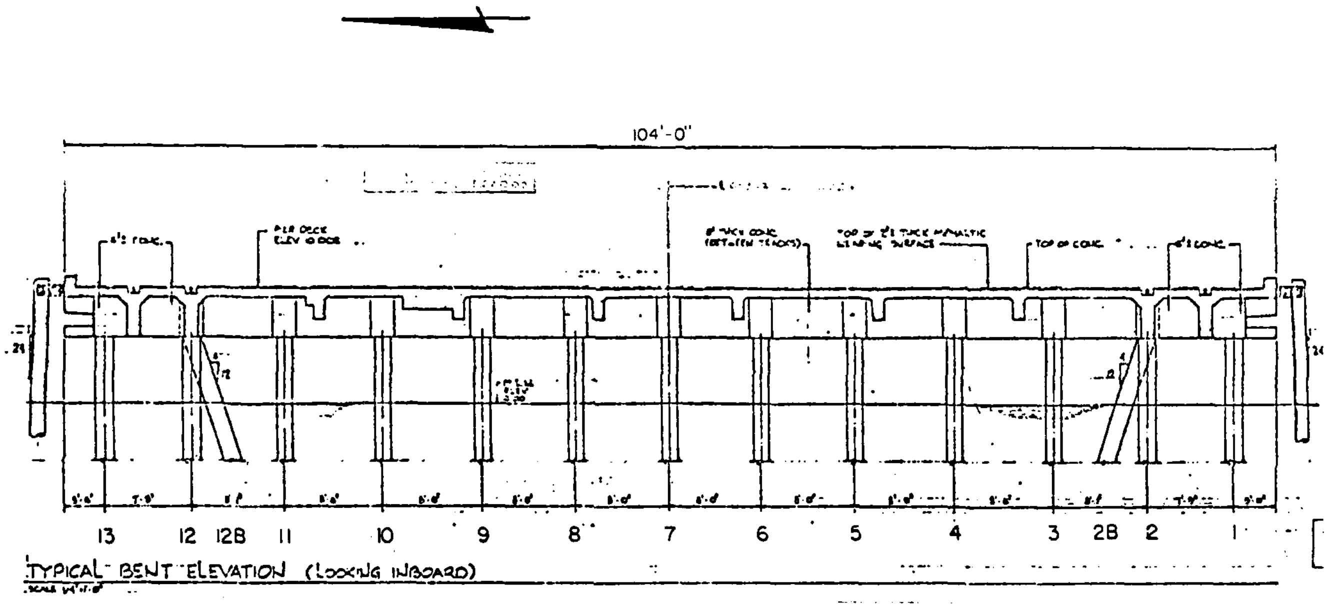
Of the 1,725 piles inspected, one (1) percent (23 piles) were observed to exhibit damage ranging from hairline cracks to completely failed piles. Only one (1) pile is considered to be in a failed condition offering no bearing to the pier structure. Throughout the length of the pier gunite had been placed on the pile caps. This gunite covered the top of the piles (six (6) to eighteen (18) inches) below the cap. The concrete surface of the piles was generally in good condition. Some pile faces were slightly pitted such that the aggregate is visible. Photographs 1 through 4 show conditions observed at Pier 5. Figures 12, 13, 14 and 15 show the general pier pile plan and observed conditions. A tabulated summary of inspection observations appears in the Appendix (pages A-6, A-18 and A-19).

4.2.3 Structural Condition Assessment

Pier 5 is in overall good condition. The damaged piles appear to have been damaged either by direct impact to the piles, or by deterioration due to exposure to the elements.

4.2.4 Recommendations

All piles exhibiting minor damage, such as cracks and light spalling, should be sealed so as to prevent salt water from



NOTES:

1. 12 INDICATES PILE IDENTIFICATION NUMBER

2. FROM GOVERNMENT FURNISHED INFORMATION

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TYPICAL
CROSS SECTION
THRU PIER 5

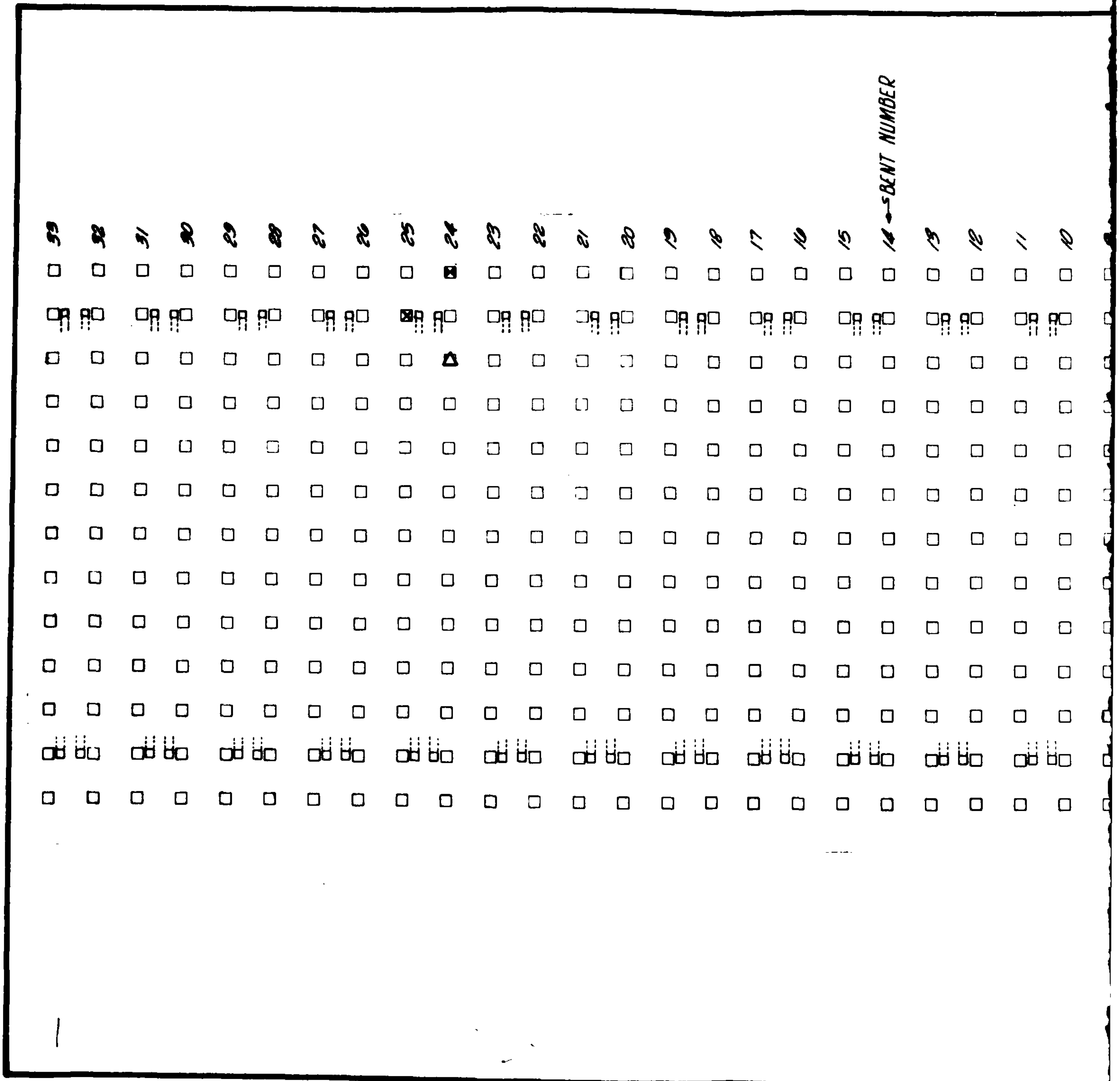
FIGURE 11

Photo No. 1
Pier 5 - Close-up underwater photo of oyster and diver's hand taken in very turbid water (typical). (This extremely poor visibility typifies general conditions at the Naval Station.)

Photo No. 2
Pier 5 - Highly turbid water photo of pile face after cleaning. Concrete is in good condition, white marks are deposits by barnacles (typical).

Photo No. 3
Pier 5 - Batter and vertical piles with hairline cracks and rust stains (Bent 89).

Photo No. 4
Pier 5 - Lightly spalled pile with gunite applied at cap; note gunite over top of pile (typical).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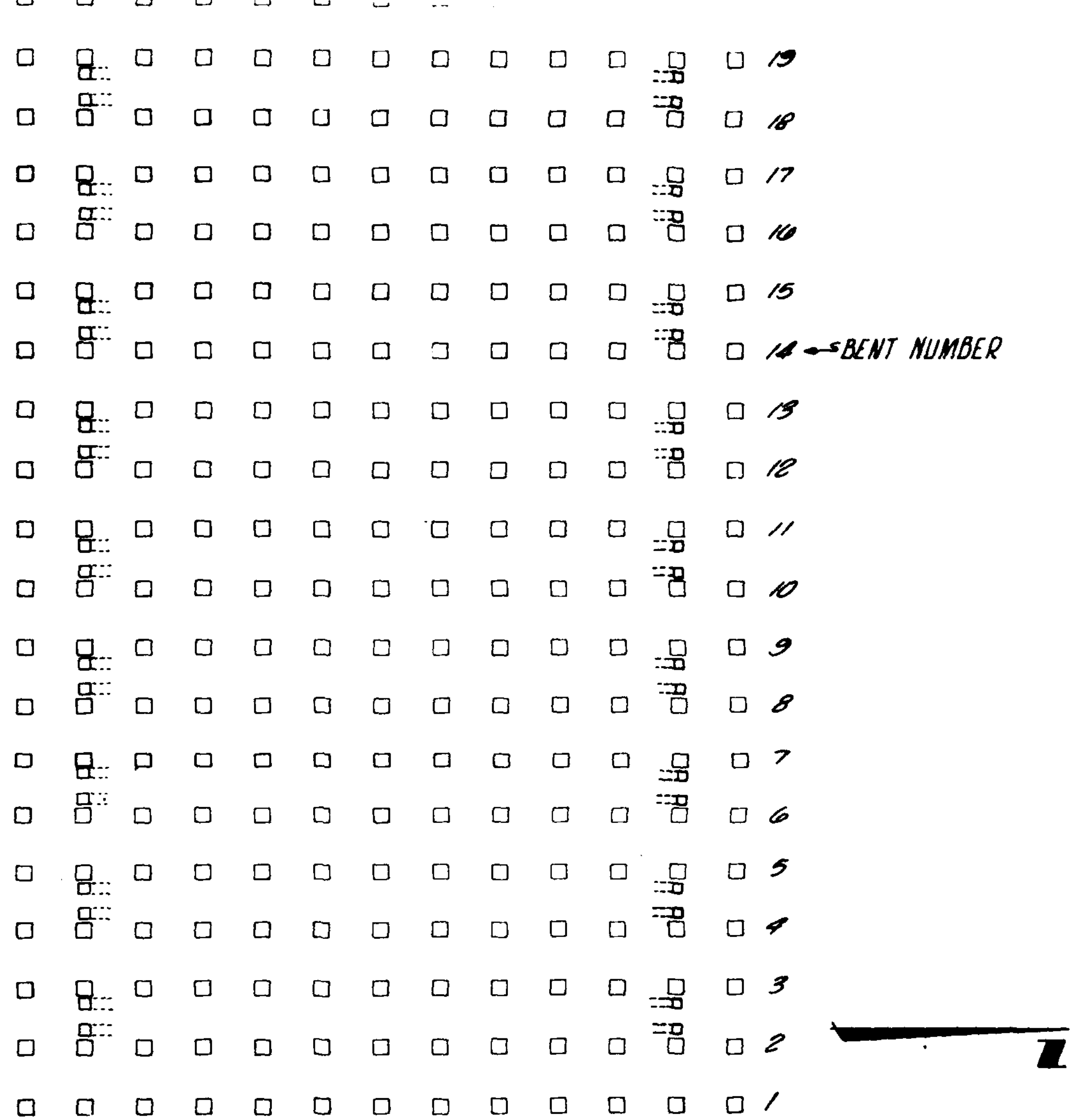

PIER LENGTH: 1,054 FT.
PIER WIDTH: 104 FT
BENT SPACING: 12 FT.

GRAPHIC KEY (N.T.S.)

Symbol		Description	Code
□	=	GOOD CONDITIONS W/ NO APPARENT PROBLEMS	C0
⊠	=	HAIRLINE CRACKS	C1
■	=	FAILURE CRACKS	C2
◘	=	SPALLED CONCRETE ON SURFACE	C3
○	=	DEEPLY SPALLED CONCRETE	C4
●	=	FAILED PILE (NO APPARANT BEARING CAPACITY)	C5

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NAVAL STATION NORFOLK, VIRGINIA

PIER 5 PLAN

FIGURE 12

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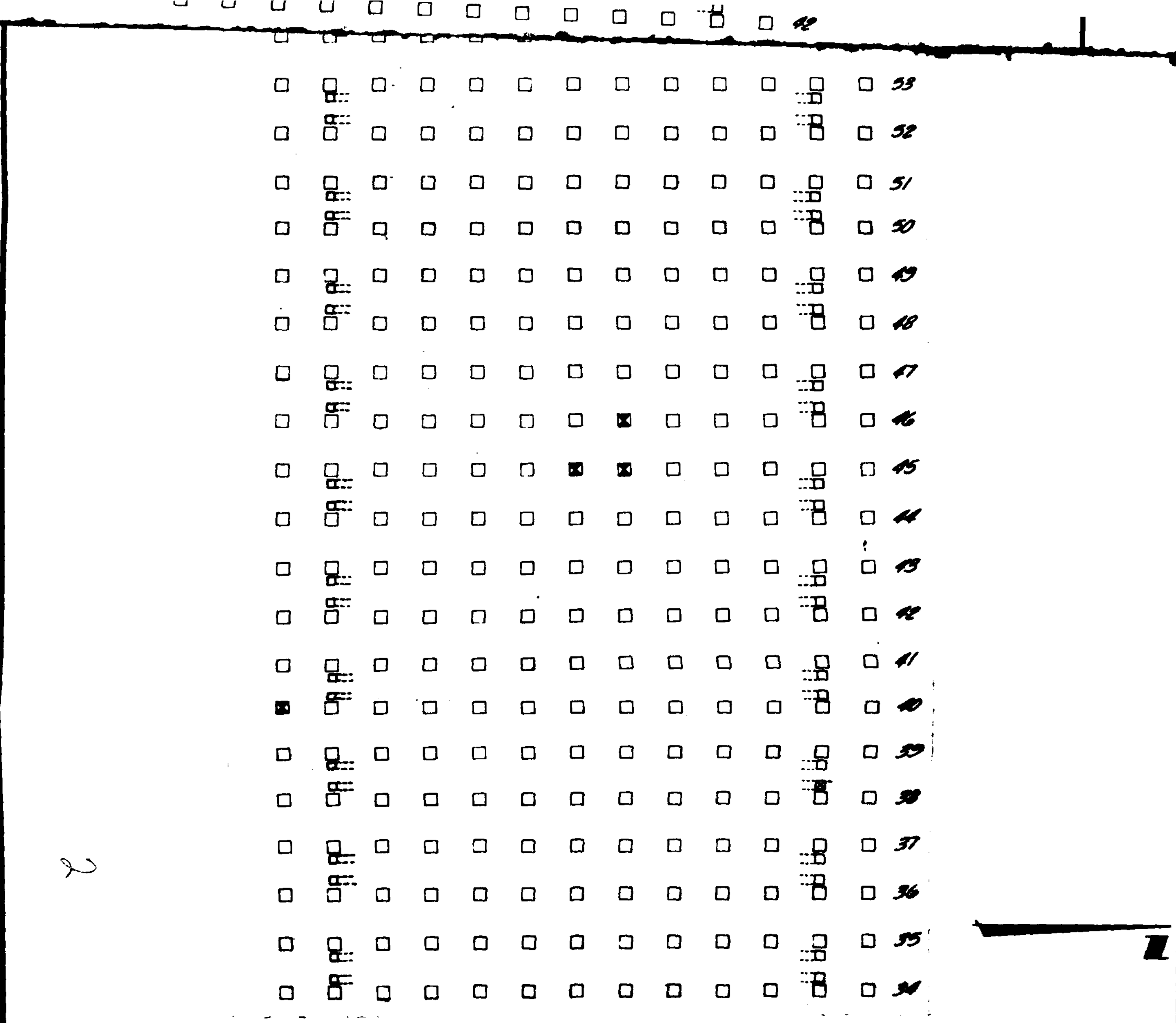

GRAPHIC KEY (N.T.S.)

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- ○ = DEEPLY SPALLED CONCRETE
- ● = FAILED PILE (NO APPARANT BEARING CAPACITY)

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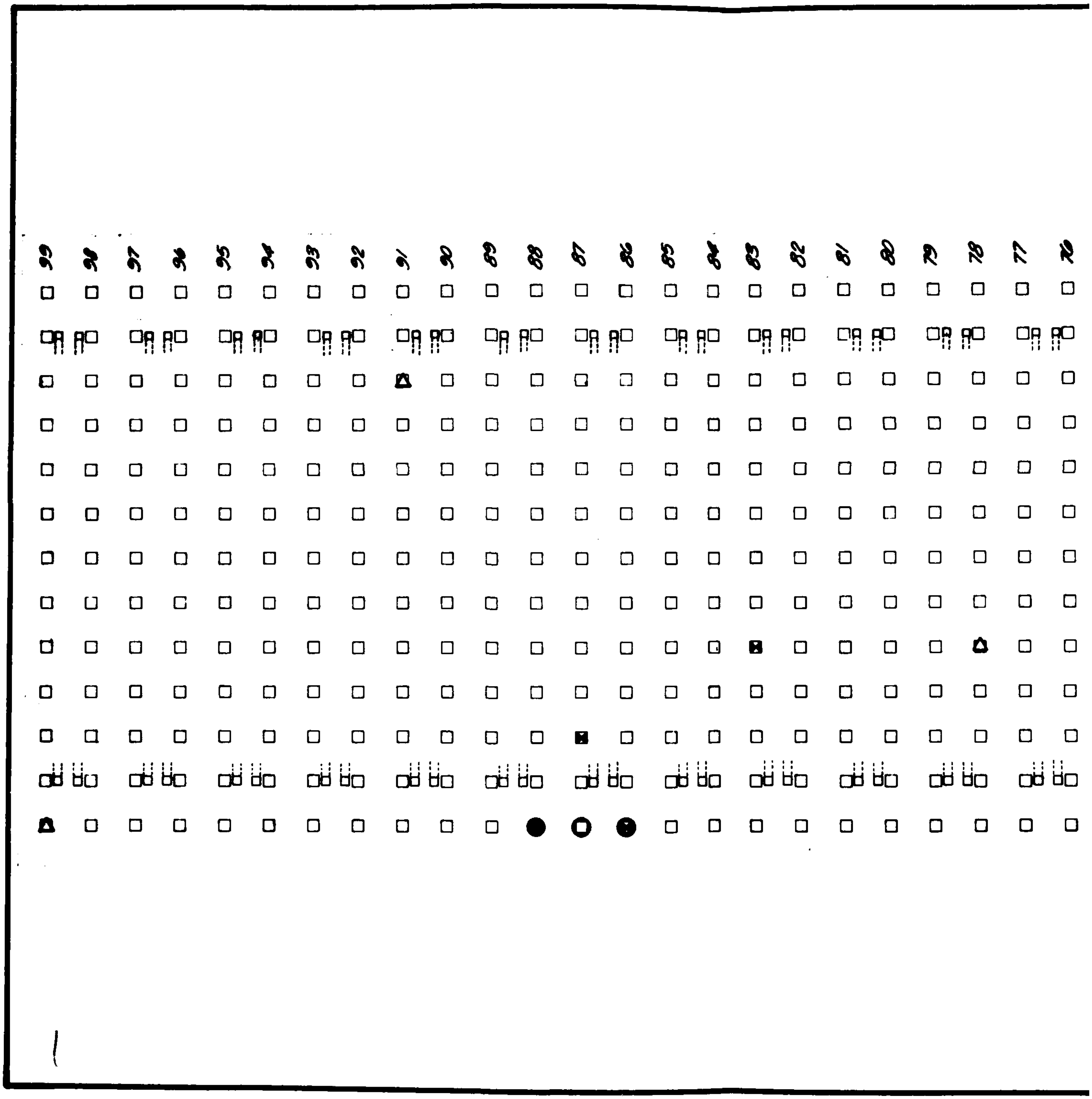
NAVAL STATION NORFOLK, VIRGINIA

PIER 5 PLAN

FIGURE 13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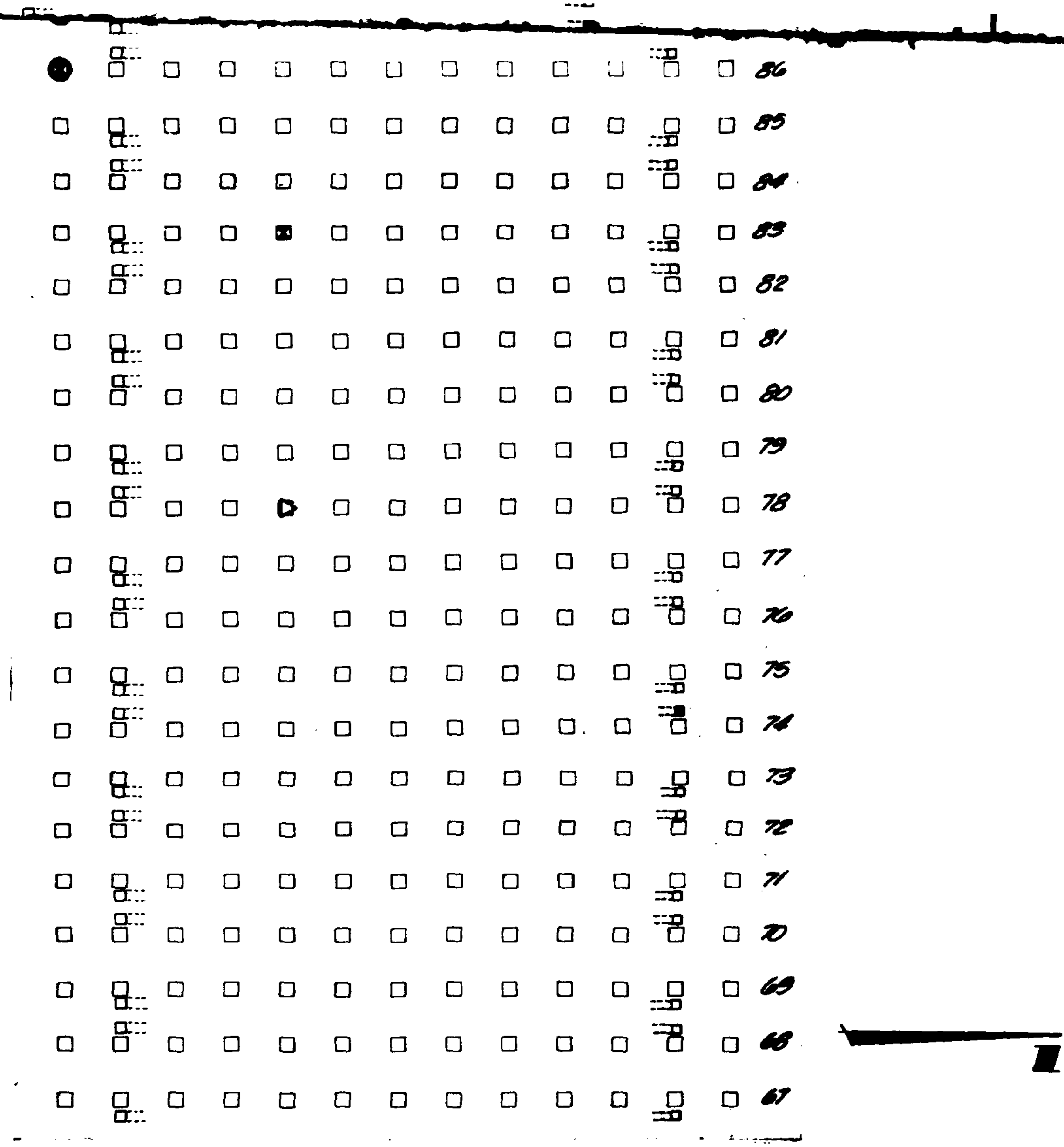

GRAPHIC KEY (N.T.S.)

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- ☒ = HAIRLINE CRACKS
- ■ = FAILURE CRACKS
- △ = SPALLED CONCRETE ON SURFACE
- ○ = DEEPLY SPALLED CONCRETE
- ● = FAILED PILE (NO APPARANT BEARING CAPACITY)

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NAVAL STATION NORFOLK, VIRGINIA

PIER 5 PLAN

FIGURE 14

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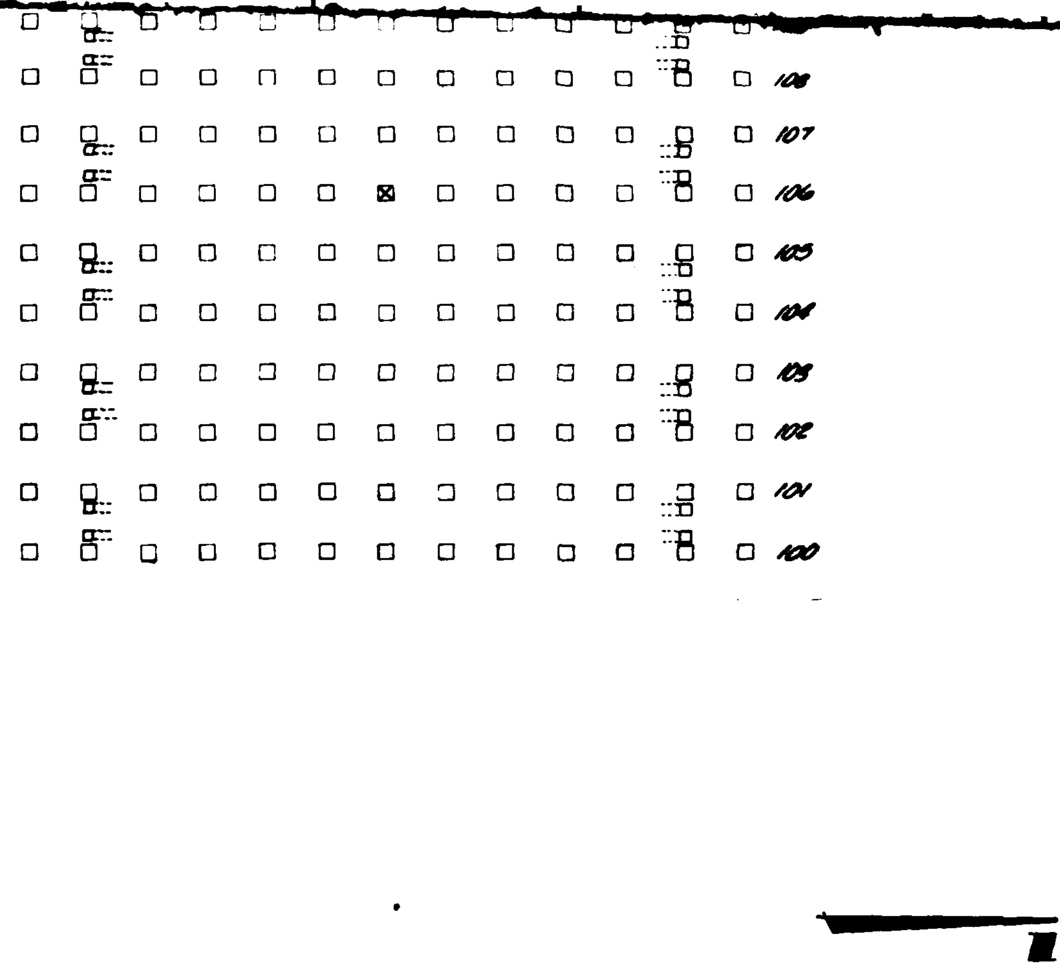

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NAVAL STATION NORFOLK, VIRGINIA

PIER 5 PLAN

FIGURE 15

2

penetrating to the reinforcing steel causing corrosion and accelerated deterioration of the piles. The seal should be made with an epoxy grout which can penetrate and seal the hairline and small failure cracks. Of the two (2) piles that have deeply spalled concrete or are failed, the greatest degree of damage is in the area of the pile cap. These piles should be repaired by chipping away concrete exposing the reinforcing steel, sand blasting the rusted reinforcing steel, and reconstruction of the damaged section by pouring a collar with additional steel reinforcement as required (see Appendix). The estimated cost of all repairs to Pier 5 is $2,450.

With completion of the above-cited repairs, the expected life of the piles is 25 years. Without these repairs, the expected life of the piles is three (3) to eight (8) years. If repairs are not soon undertaken, the cost and extent of the needed repairs is expected to increase as further deterioration occurs.

The entire pier should be inspected at least once every six (6) years. The pier should also be inspected following any ship-pier collisions to assess damage, if any, to the pier. Once every two (2) years, a cursory inspection by Activity personnel should be performed by boat at low tide to determine any extensive damage to exterior piles which are most susceptible to damage.

4.3 Pier Number 7

4.3.1 Description

Pier 7 is constructed of reinforced concrete and is located to the north of Pier 5 and to the south of the small craft basin. Figure 10 shows the location of Pier 7 on base. The pier has a length of 1,352 feet and width of 104 feet. The pier was constructed in 1931. A total of 1,960 reinforced concrete piles support the pier. The deck of Pier 7 is supported by 115 bents. Each bent is composed of 13 bearing piles and two (2) batter piles. Figure 16 shows a typical bent for Pier 7. During the period of inspection, replacement of the fender pile system along the northern outboard section of Pier 7 was being performed. This operation required the inspection team to temporarily discontinue inspection of Pier 7 due to heavy equipment working in close proximity to the exterior piles and large amounts of floating debris on the water surface.

4.3.2 Observed Inspection Condition

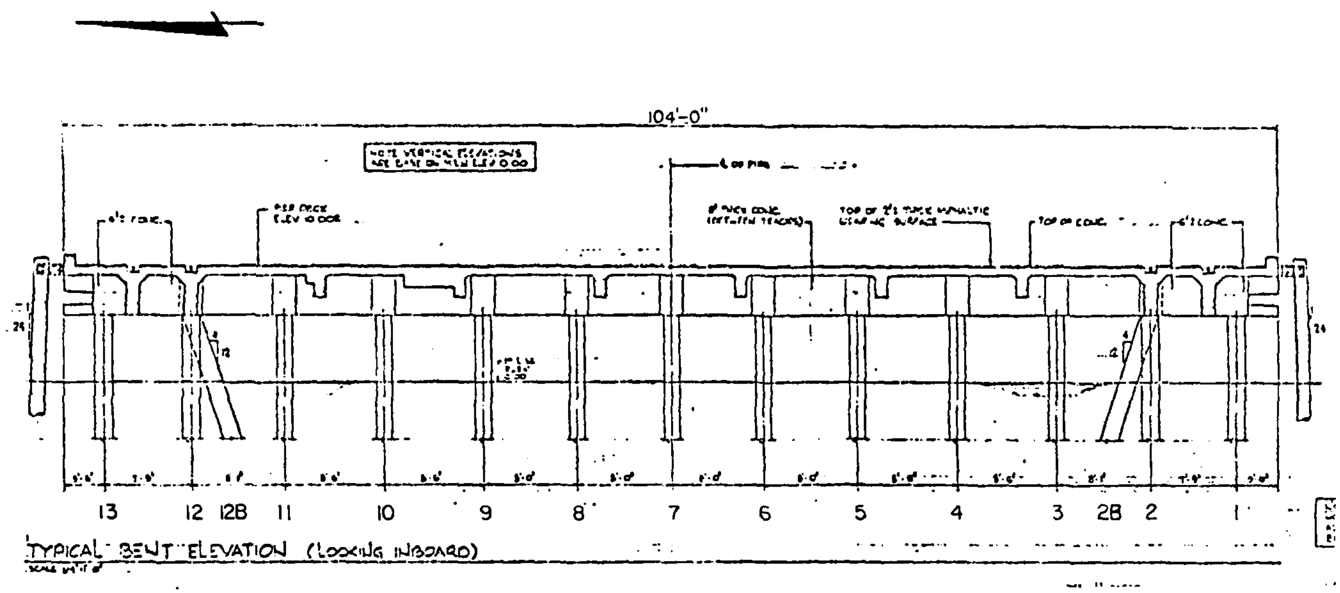
Pier 7 is in overall good condition. A total of six (6) percent of the piles (118 piles) exhibited damage ranging from hairline cracks to completely failed piles. Only two (2) piles were observed to be in a failed condition offering no support to the pier structure. Photographs 1 through 4 of Pier 5 typify conditions observed at Pier 7. A tabulated summary of inspection observations appears in the Appendix (pages A-7 through A-9, A-20 and A-21). Figures 17, 18, 19 and 20 show the general pile plan and inspection observations.

4.3.3 Structural Condition Assessment

Pier 7 is in overall good condition. The damaged piles appear to have been damaged either by direct impact to the piles, or by deterioration due to exposure to the elements.

4.3.4 Recommendations

All piles exhibiting minor damage, such as cracks and light spalling, should be sealed so as to prevent salt water from penetrating to the reinforcing steel causing corrosion and accelerated deterioration of the piles. The seal should be made with an epoxy grout which can penetrate and seal the hairline and small failure cracks. Of the piles that have deeply spalled concrete or are failed, the greatest degree of damage is in the area of the pile cap. These piles should be repaired by chipping away concrete exposing the



NOTES:

1. 3 INDICATES PILE IDENTIFICATION NUMBER.

2. FROM GOVERNMENT FURNISHED INFORMATION

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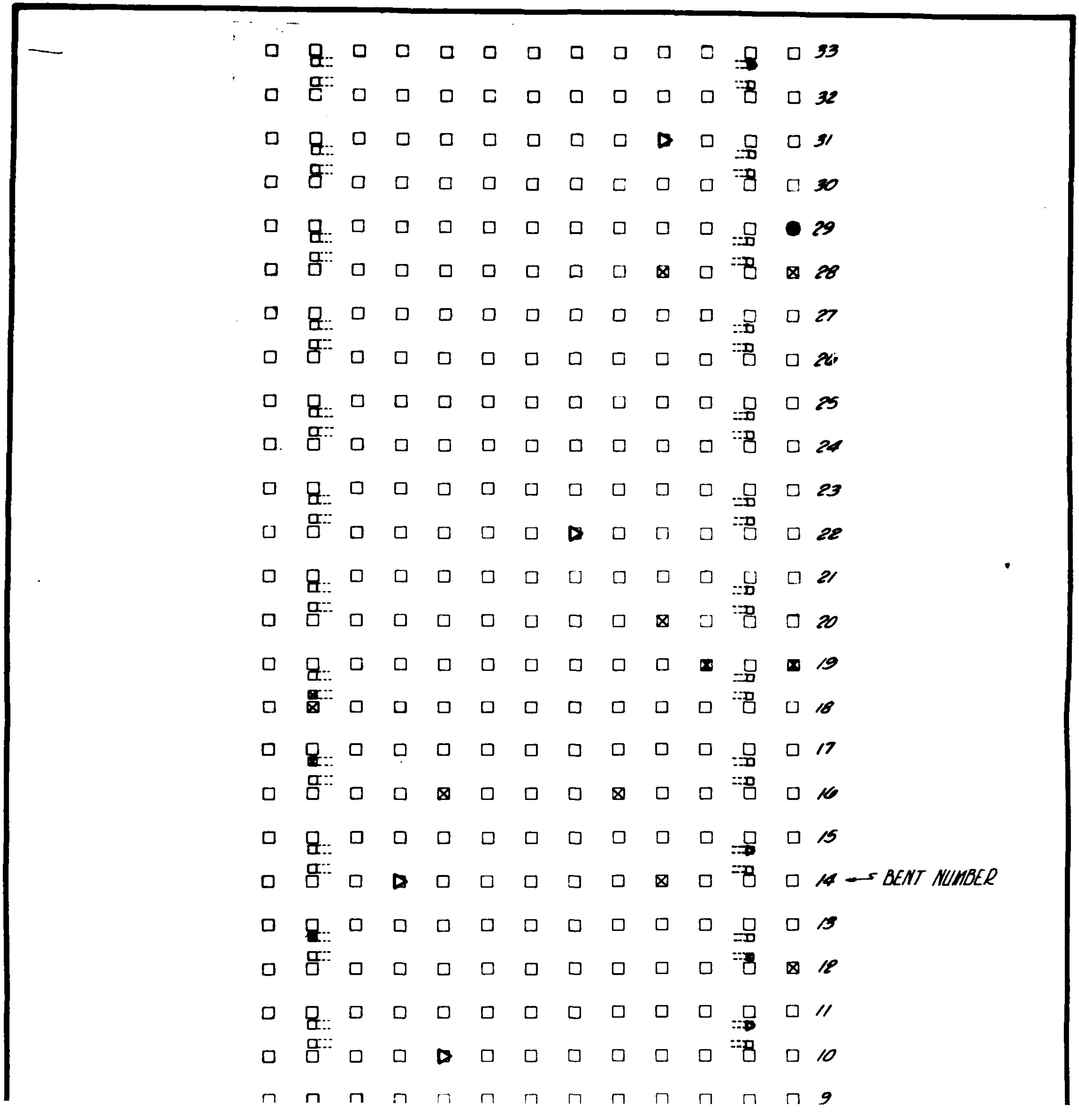
TYPICAL CROSS SECTION THRU PIER 7

FIGURE 16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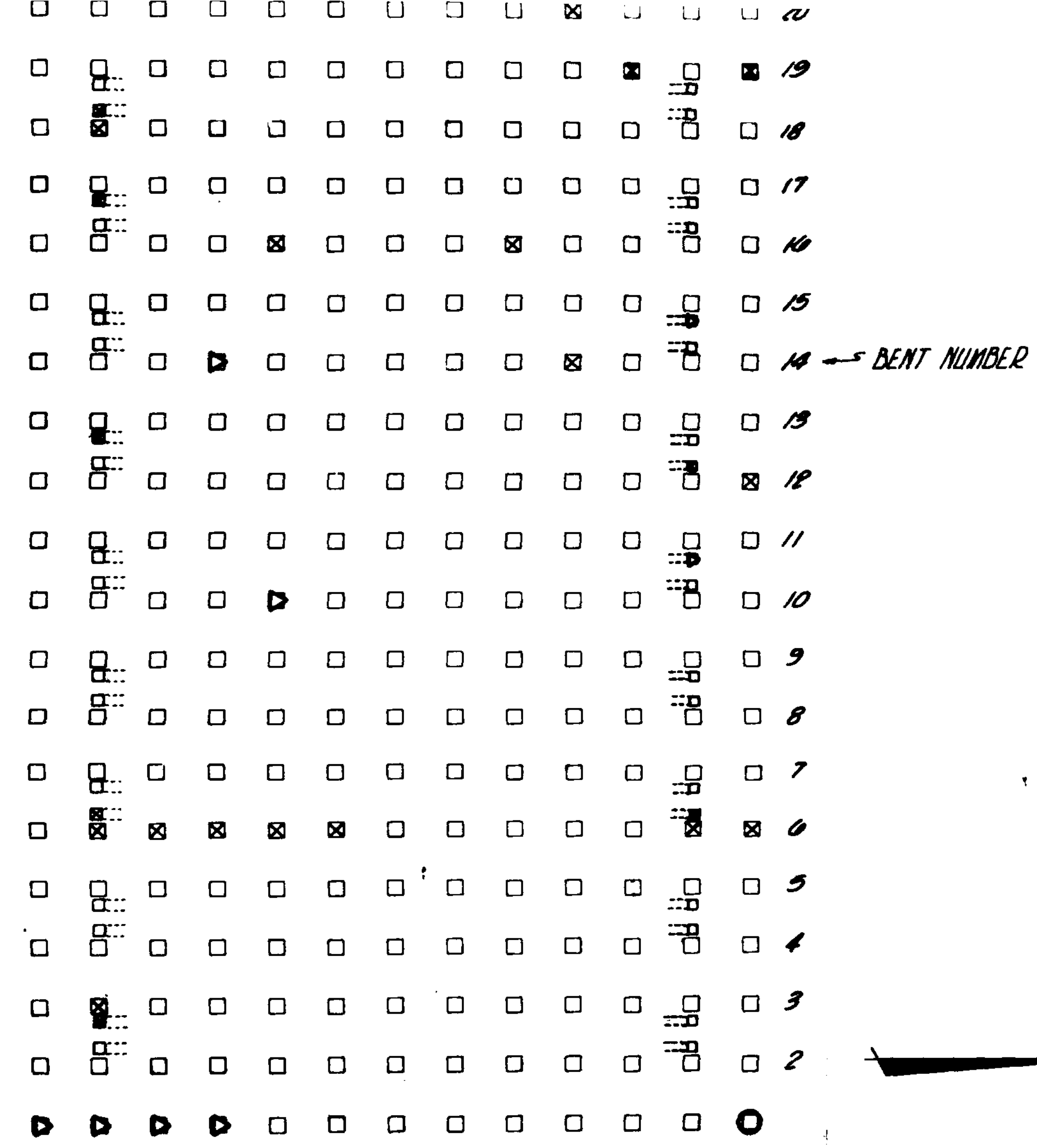

PIER LENGTH: 1,352 FT.
PIER WIDTH: 104 FT.
BENT SPACING: 12 FT.

GRAPHIC KEY (N.T.S.)

Symbol	Description	Code
☐ =	GOOD CONDITIONS W/NO APPARENT PROBLEMS	C0
☒ =	HAIRLINE CRACKS	C1
■ =	FAILURE CRACKS	C2
△ =	SPALLED CONCRETE ON SURFACE	C3
○ =	DEEPLY SPALLED CONCRETE	C4
● =	FAILED PILE (NO APPARANT BEARING CAPACITY)	C5

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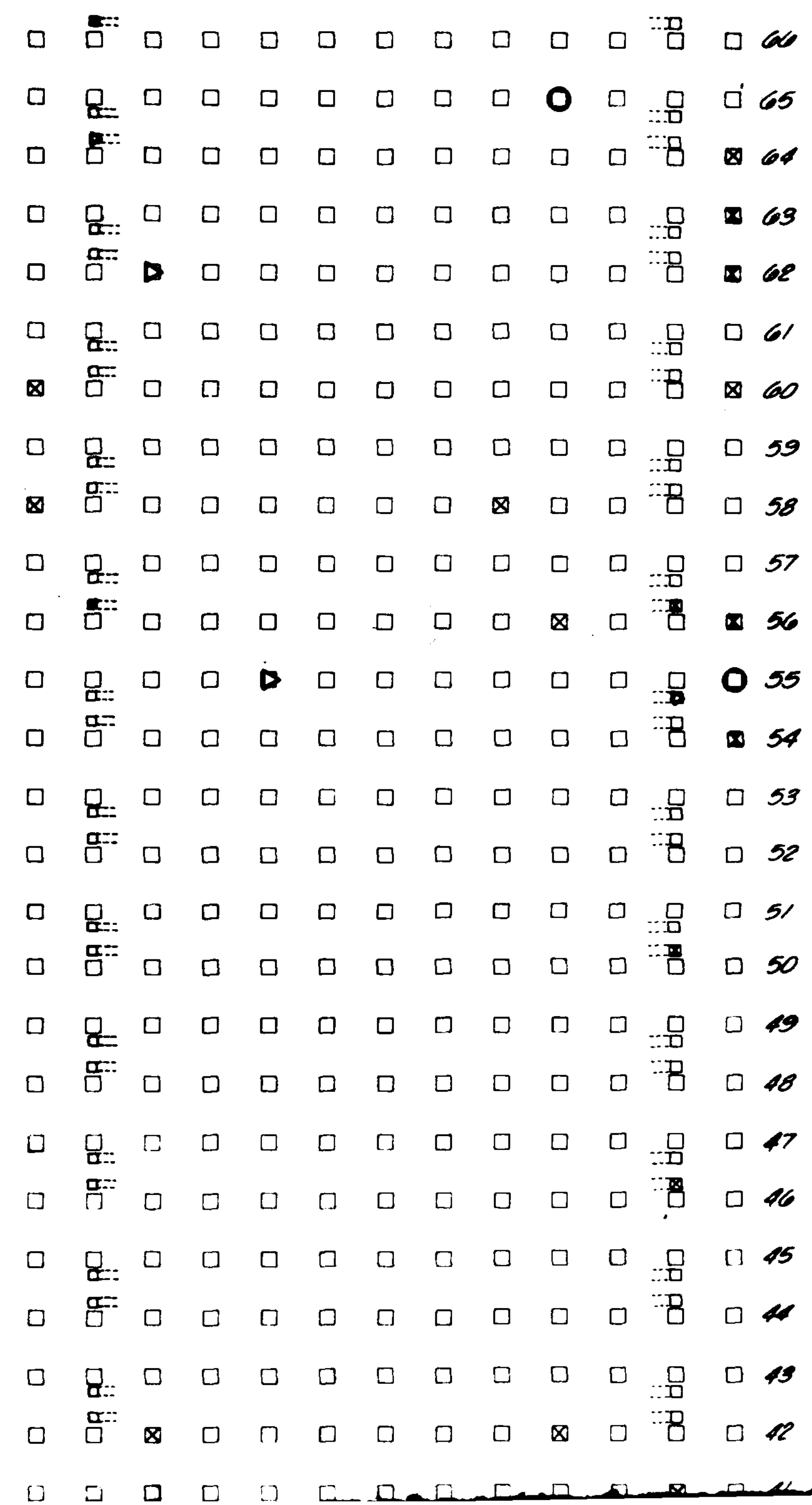
NAVAL STATION NORFOLK, VIRGINIA

PIER 7 PLAN

FIGURE 17



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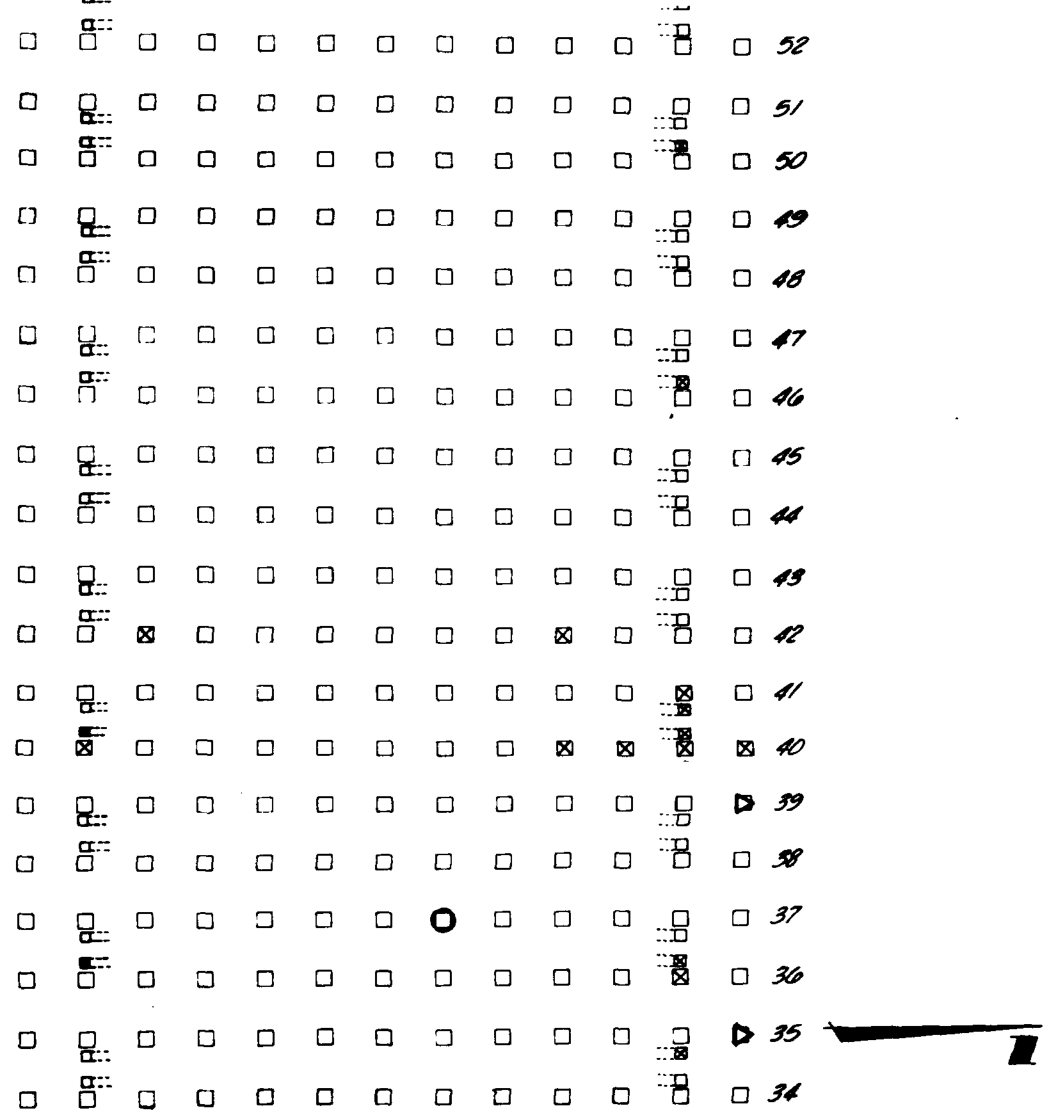

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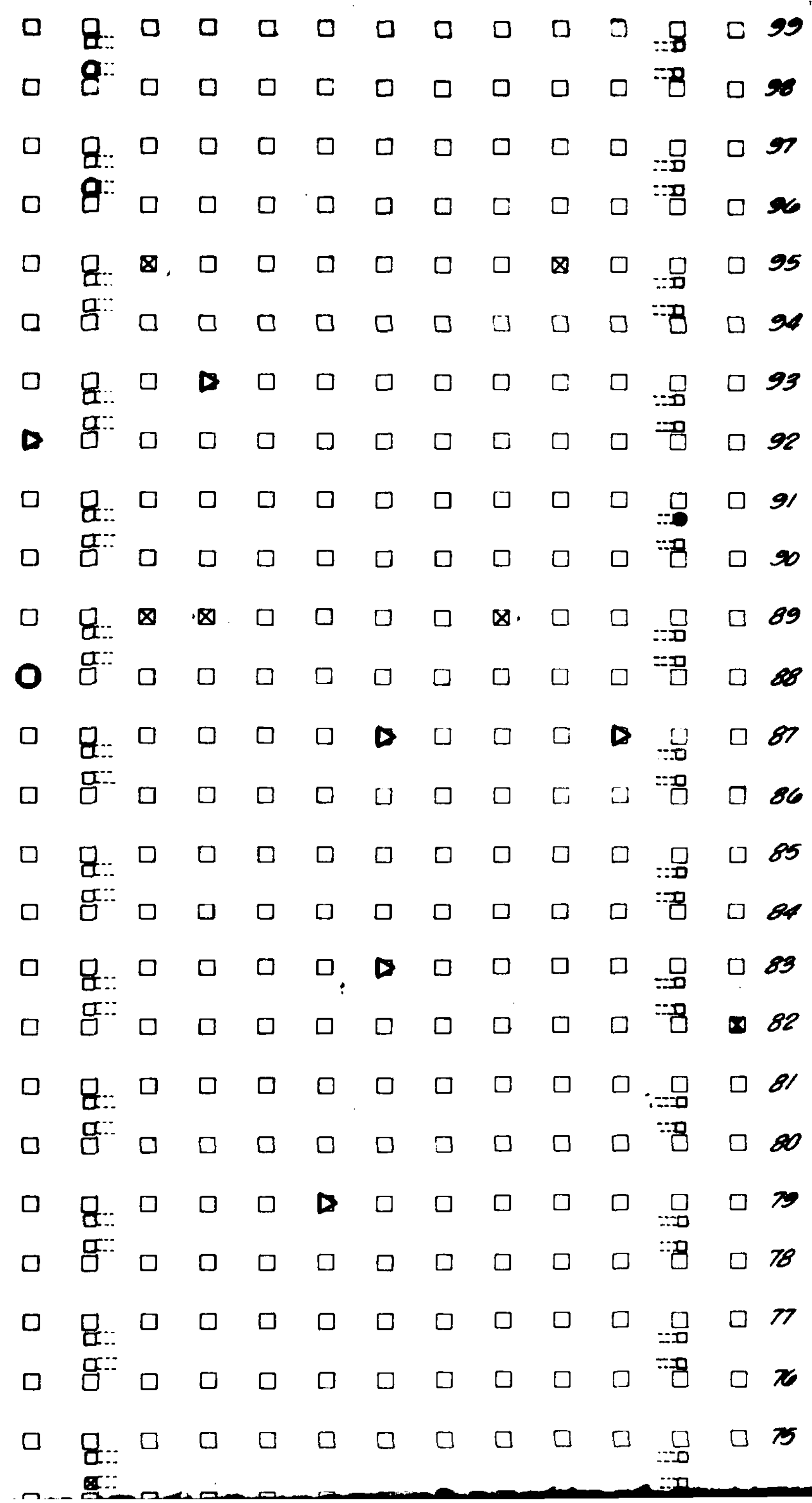
PIER 7 PLAN

FIGURE 18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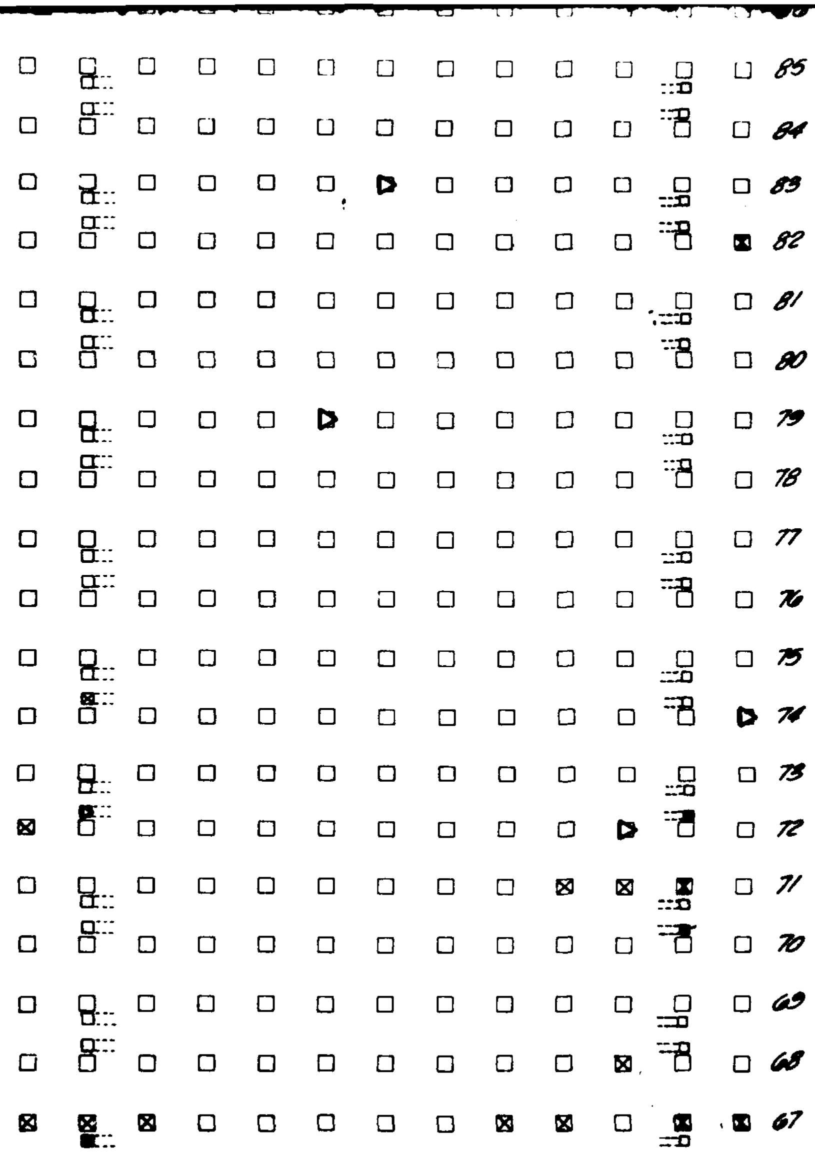

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PIER 7 PLAN

FIGURE 19

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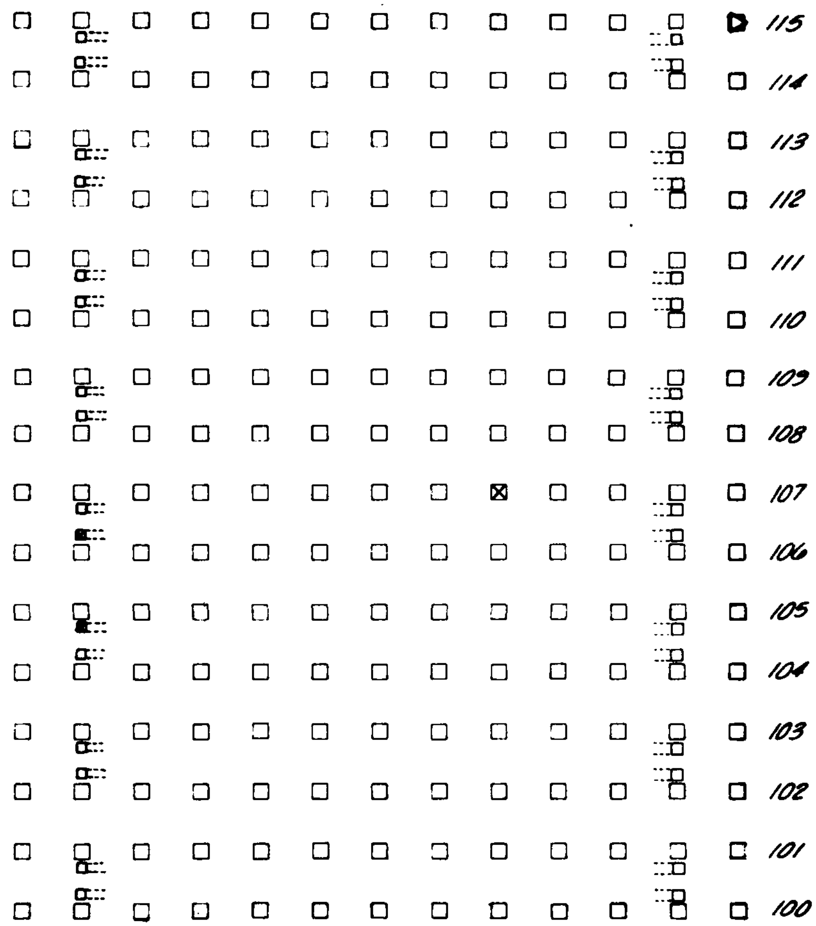

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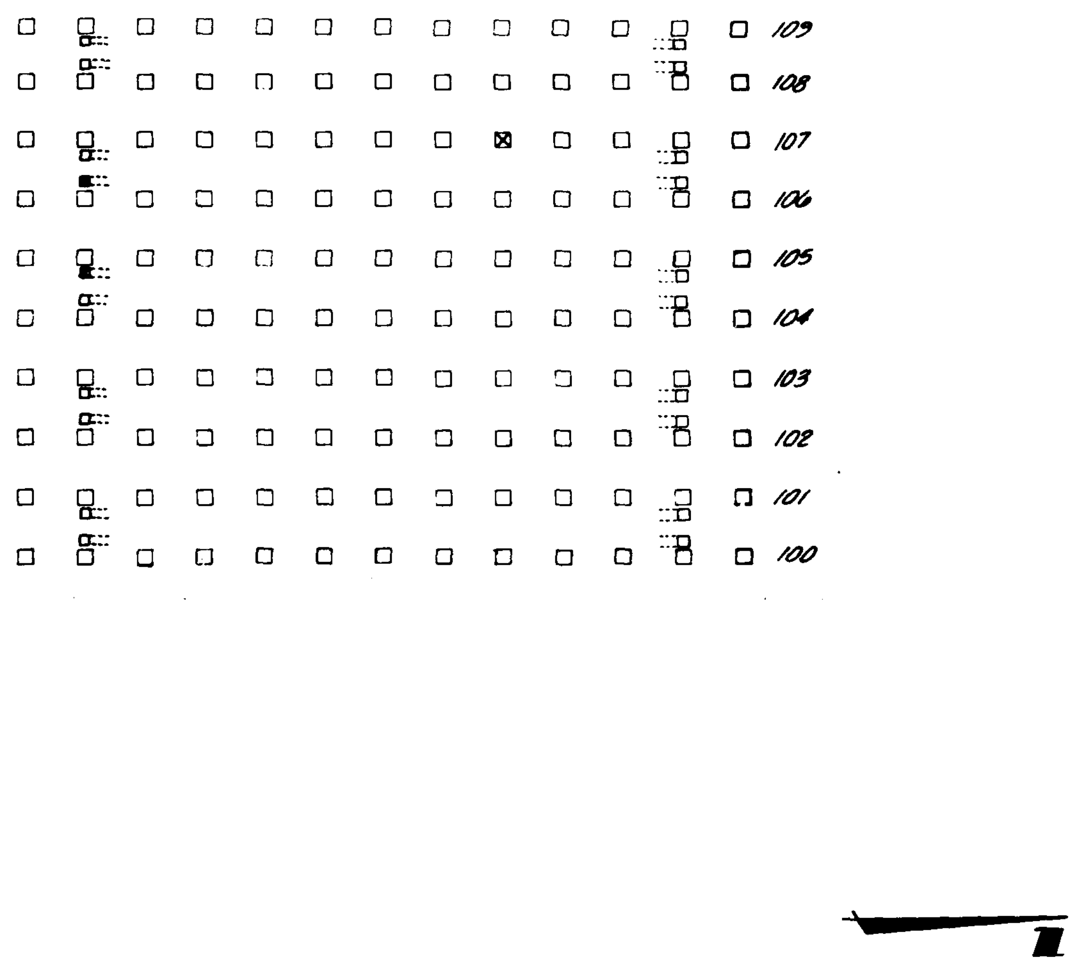

GRAPHIC KEY (N.T.S.)

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- ⊠ = HAIRLINE CRACKS
- ■ = FAILURE CRACKS
- △ = SPALLED CONCRETE ON SURFACE
- ○ = DEEPLY SPALLED CONCRETE
- ● = FAILED PILE (NO APPARANT BEARING CAPACITY)

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NAVAL STATION NORFOLK, VIRGINIA

PIER 7 PLAN

FIGURE 20

2

reinforcing steel, sand blasting rusted reinforcing steel, and reconstruction of the damaged section by pouring a collar with additional steel reinforcement as required. The estimated cost of all repairs to Pier 7 is $8,575.

With completion of the above-cited repairs, the expected life of the piles is 20 years. Without these repairs, the expected life of the piles is two (2) to seven (7) years. If repairs are not soon undertaken, the cost and extent of the needed repairs is expected to increase as further deterioration occurs.

The entire pier should be inspected at least once every six (6) years. The pier should also be inspected following any ship-pier collisions to assess damage, if any, to the pier. Once every two (2) years, a cursory inspection by Activity personnel should be performed by boat at low tide to determine any extensive damage to exterior piles which are most susceptible to damage.

4.4 Pier Number 12

4.4.1 Description

Pier 12 was the largest pier inspected, having an overall length of 1,306 feet and a width of 150 feet. It is constructed of reinforced concrete and supported by 2,250 reinforced concrete piles. The pier is located at the north end of the Naval station. Figure 10 shows the location of Pier 12 on base. The pier was constructed in 1959. In addition to the normal precautions taken with a ship to assure the safety of divers, it was also necessary to have a ship shut down its impressed- current cathodic protection system so that divers would not incur any electrical hazards while in the water. Additionally, it became necessary to abort inspection dives at one point, when storm tides caused diving conditions under the pier to become hazardous. Pier 12 is supported by 90 bents, with each bent composed of 23 bearing piles and two (2) batter piles. Figure 21 shows a typical cross-section of a bent of Pier 12.

4.4.2 Observed Inspection Condition

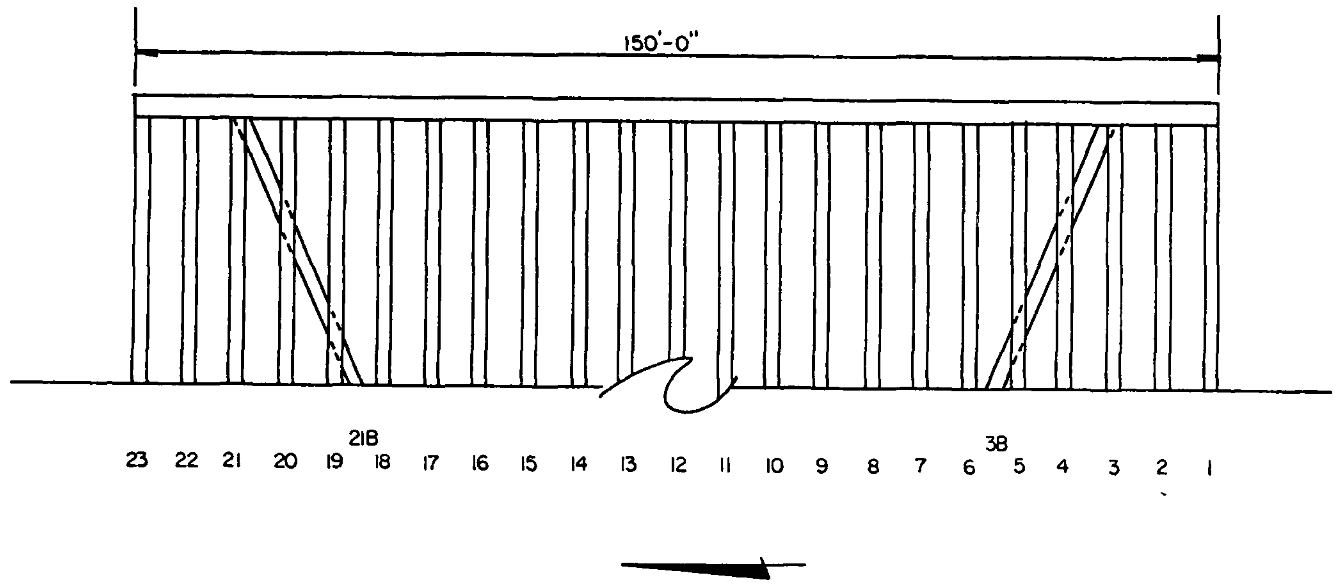
Pier 12 is in overall good condition. A total of five (5) percent of the piles (102 piles) were found to have defects ranging from hairline cracks to completely failed piles. A total of four (4) piles were found to be in a failed condition, and providing no support to the pier structure. A tabulated summary of inspection observations appears in the Appendix (pages A-10 through A-12, A-22, and A-23). Pile 1, Bent 78 was severed at the cap with failure cracks and exposed corroded steel at the waterline. Pile 23, Bent 56 was missing from the waterline to the cap. Pile 23, Bent 58 was completely missing. Figures 22, 23 and 24 show a general pile plan and the piles with damage. Photos 5 through 10 illustrate the conditions observed at Pier 12.

4.4.3 Structural Condition Assessment

Pier 12 is in overall good condition. The damaged piles appear to have been damaged either by direct impact to the piles, or by deterioration due to exposure to the elements.

4.4.4 Recommendations

All piles exhibiting minor damage, such as cracks and light spalling, should be sealed so as to prevent salt water from penetrating to the reinforcing steel causing corrosion and



NOTES:

1. 3 INDICATES PILE IDENTIFICATION NUMBER

2. FROM GOVERNMENT FURNISHED INFORMATION

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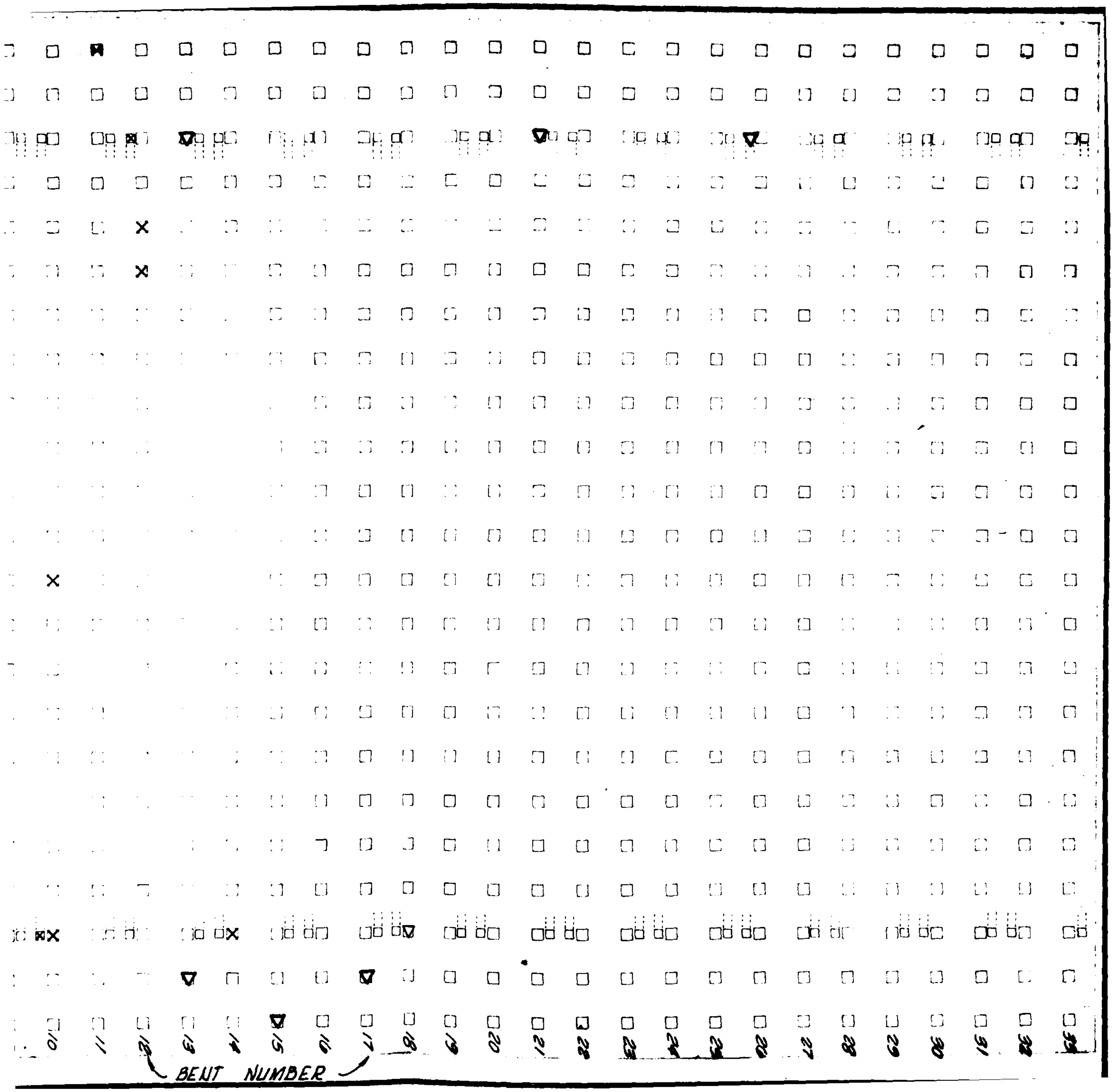
WASHINGTON, D.C.

TYPICAL
CROSS SECTION
THRU PIER 12

FIGURE 21



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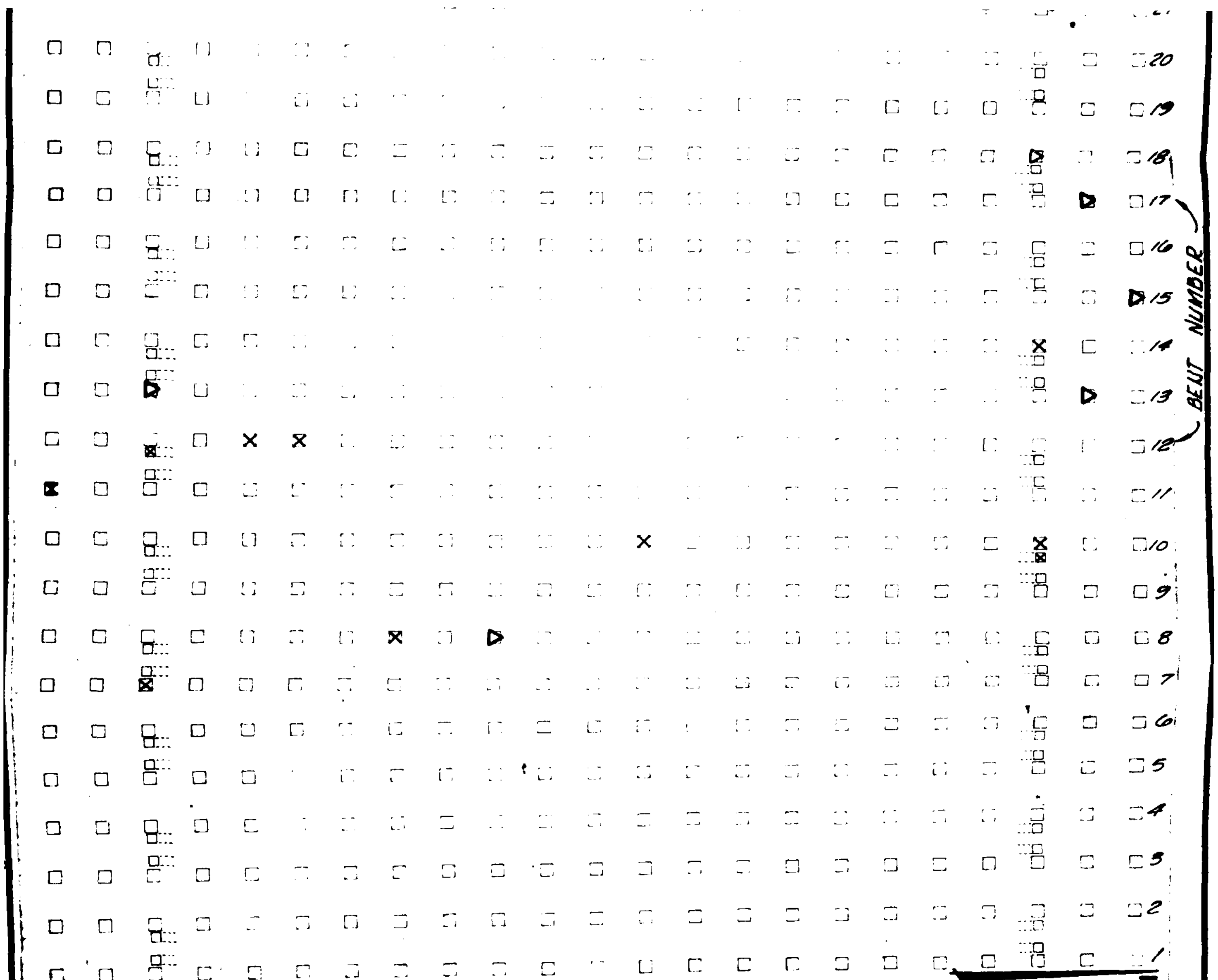
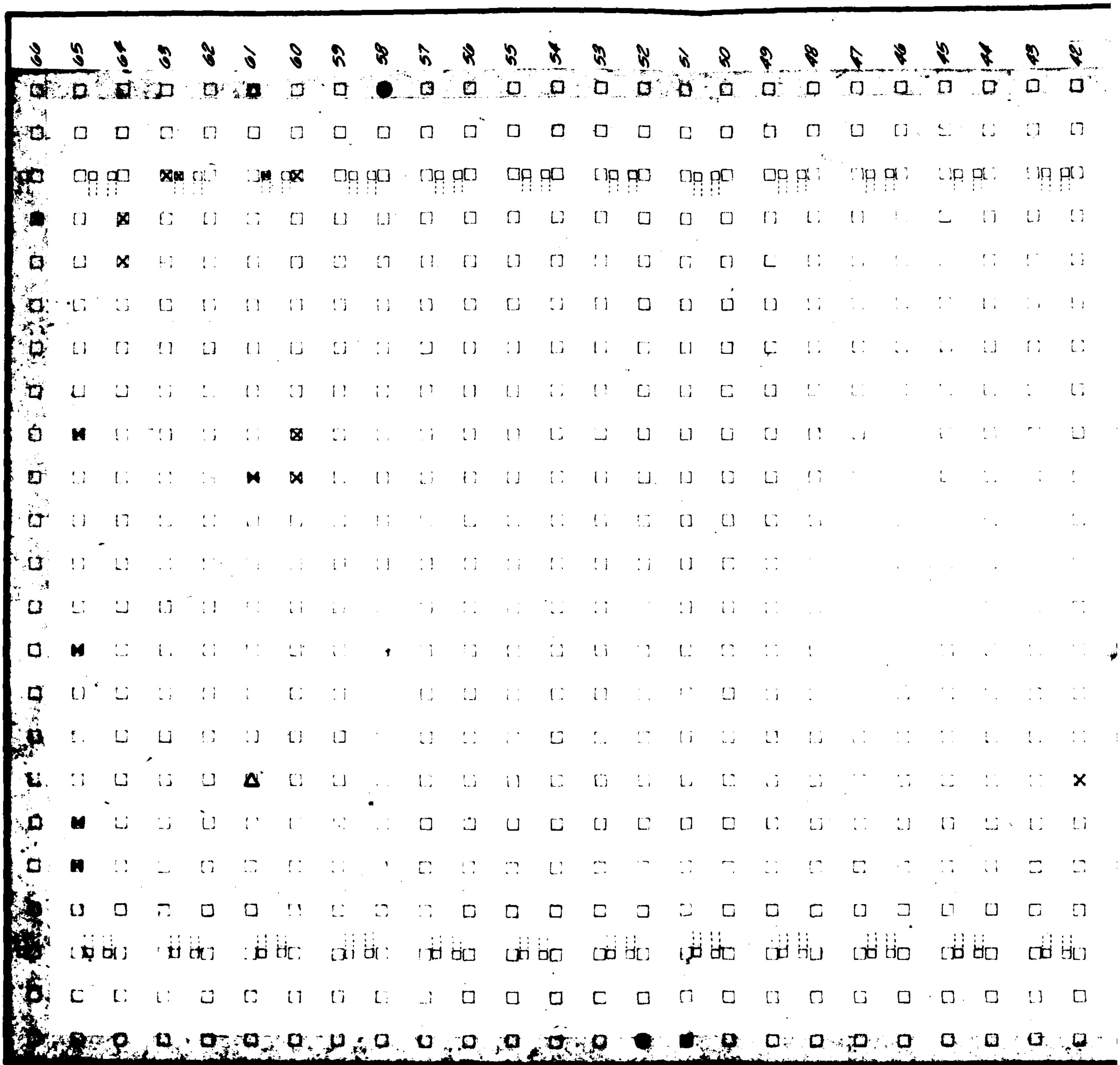


PIER LENGTH: 1306 FT. PIER WIDTH: 150 FT. BENT SPACING: 15 FT.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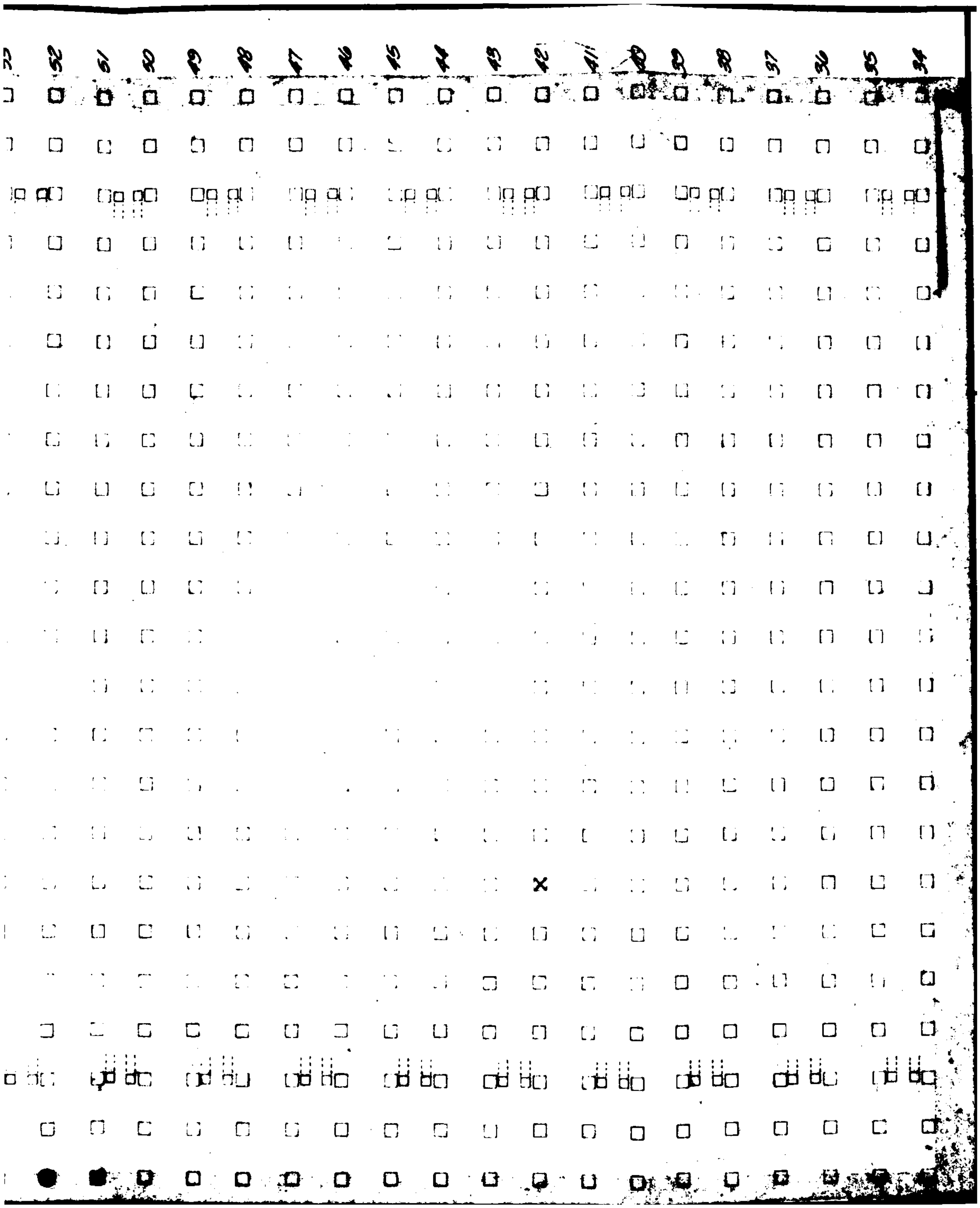
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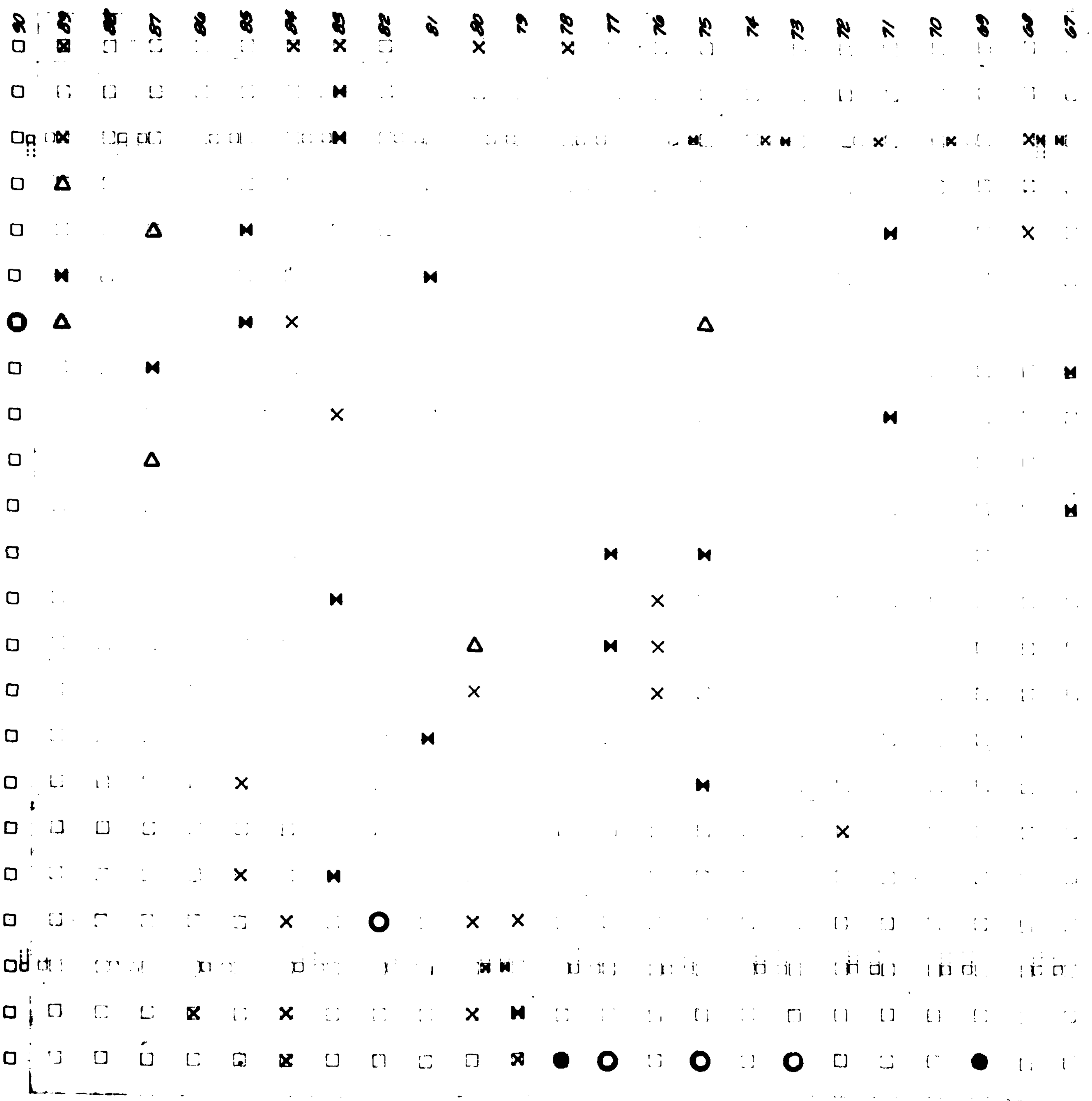
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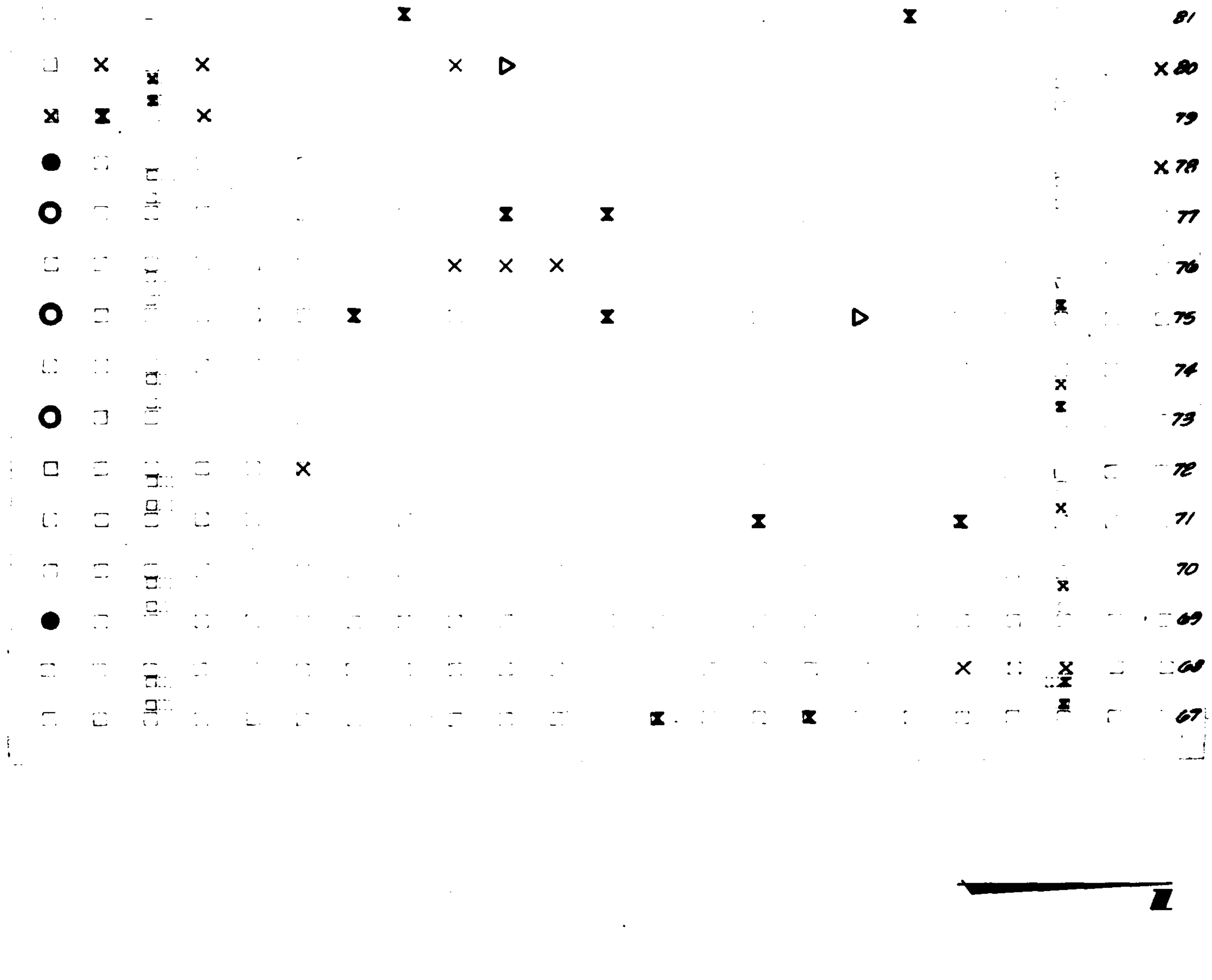

GRAPHIC KEY (N.T.S.)

- □ = GOOD CONDITIONS W/NO APPARENT PROBLEMS
- ⊠ = HAIRLINE CRACKS
- ⧗ = FAILURE CRACKS
- △ = SPALLED CONCRETE ON SURFACE
- ○ = DEEPLY SPALLED CONCRETE
- ● = FAILED PILE (NO APPARANT BEARING CAPACITY)

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WASHINGTON, D.C.

NAVAL STATION NORFOLK, VIRGINIA

PIER 12 PLAN

FIGURE 24

Photo No. 5
Pier 12 - Fender system and outboard piles (typical).

Photo No. 6
Pier 12 - Vertical pile with hairline crack and minor rust stain (typical).

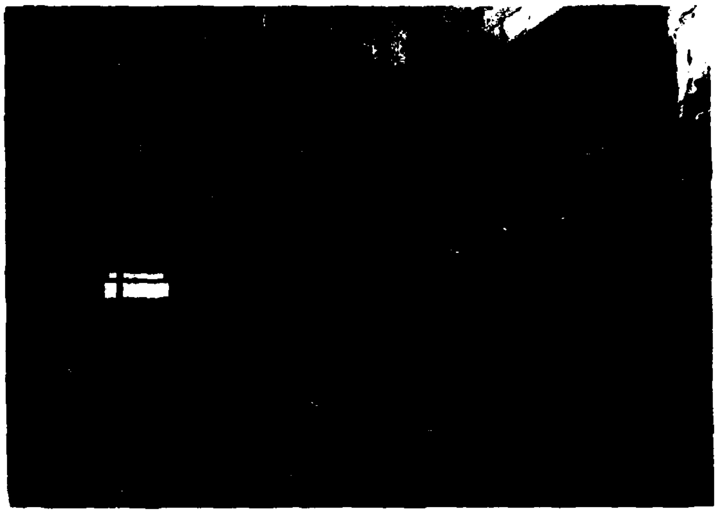


Photo No. 7
Pier 12 - Piping supported under deck of pier supported by angle. Note rust stains at angle and supports (typical).

Photo No. 8
Pier 12 - Surface spalled batter pile (Bent 88).

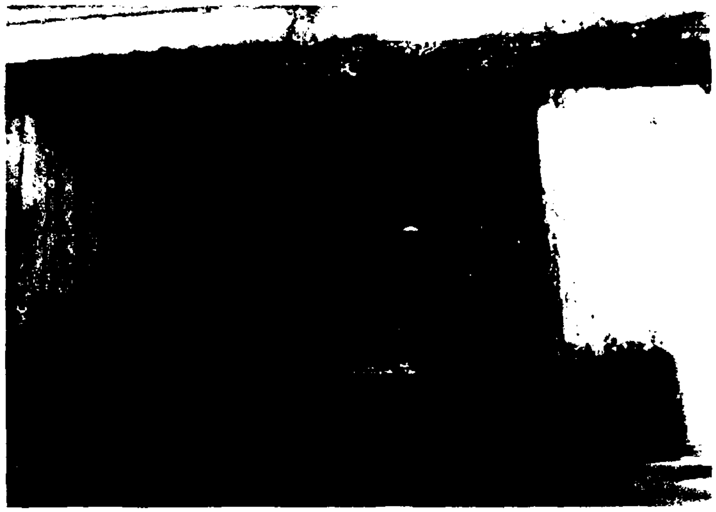


Photo No. 9
Pier 12 - Two piles with hairline cracks and rust stains. The "dropped" concrete sections contain a compartment for ship-to-shore utility connections (typical).

Photo No. 10
Pier 12 - Bent at low tide. Note good condition on underside of pier deck and pile cap (typical).

accelerated deterioration of the piles. The seal should be made with an epoxy grout which can penetrate and seal the hairline and small failure cracks. Of the piles that have deeply spalled concrete or are failed, the greatest degree of damage is in the area of the pile cap. These piles should be repaired by chipping away concrete exposing the reinforcing steel, sand blasting the rusted reinforcing steel, and reconstruction of the damaged section by pouring a collar with additional steel reinforcement as required. One (1) pile was completely missing (see Appendix); and must be completely replaced. Pile replacement requires removal of the pier deck and pile cap for placement and driving of the new pile. The deck and pile cap must be restored following installation of the new pile. The estimated cost of all repairs to Pier 12 is $11,150.

With completion of the above-cited repairs, the expected life of the piles is 30 years. Without these repairs, the expected life of the piles is five (5) to ten (10) years. If repairs are not soon undertaken, the cost and extent of the needed repairs is expected to increase as further deterioration occurs.

The entire pier should be inspected at least once every six (6) years. The pier should also be inspected following any ship-pier collisions to assess damage, if any, to the pier. Once every two (2) years, a cursory inspection by Activity personnel should be performed by boat at low tide to determine any extensive damage to exterior piles which are most susceptible to damage.

4.5 Pier Number 20

4.5.1 Description

Pier 20 is a 1,451 foot long by 50 foot wide reinforced concrete structure, located at the south end of the Naval facility. Figure 10 shows the location of Pier 20 on base. The pier was constructed in 1942. Typical cross-sections are shown in Figure 25. Each bent has nine (9) vertical piles and two (2) batter piles. This pier has 1,056 reinforced concrete piles. In addition to undergoing recent repairs for damage which occurred from the impact of a ship at the outboard end, Pier 20 has also recently been extended. This extension does not appear on plans supplied to the inspectors. However, all piles supporting this extension were inspected.

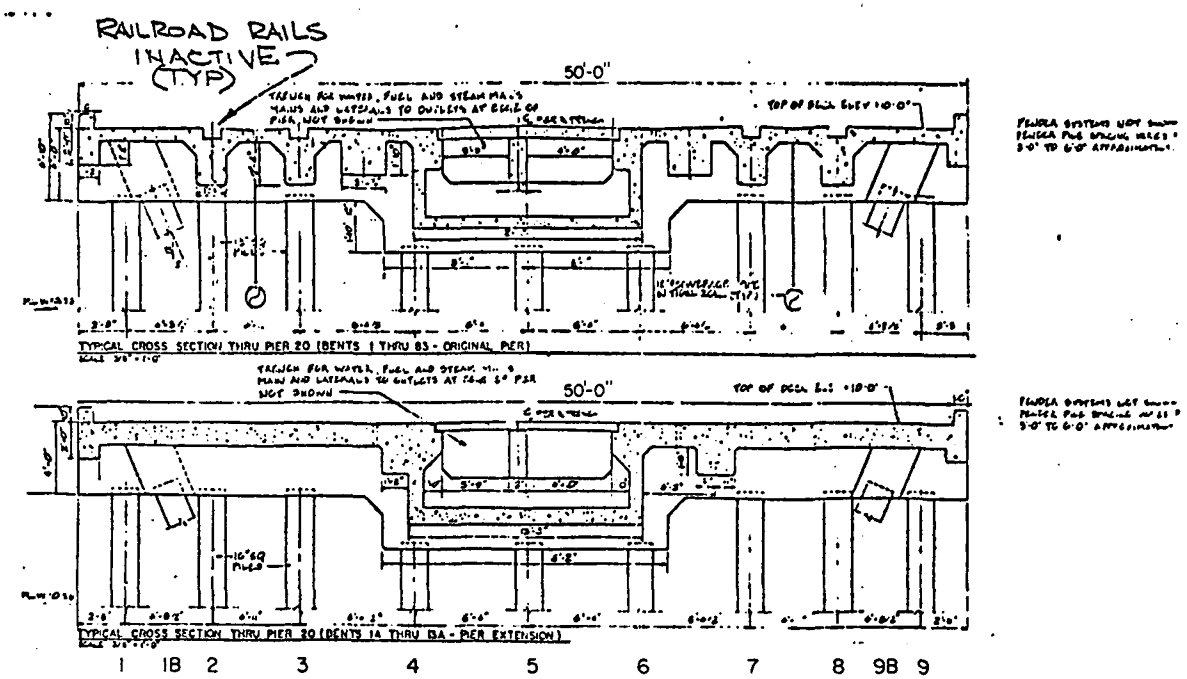
4.5.2 Observed Inspection Condition

A total of 1,056 piles were inspected on a Level I basis under Pier 20. Of this total number of piles, six (6) percent, or 67 piles, showed defects ranging from small hairline cracks to completely failed piles offering no support to the pier structure. Of these 67 piles showing defects, two (2) percent, or 17 piles, are considered to be in a failed condition (i.e., no apparent bearing capacity). All damage was found in the tidal and splash zone. Most damage was found immediately below the cap. Figures 26, 27 and 28 show the general pile plan of the pier and identifies the damaged piles.

All piles on Bents 95 and 94 were observed to have steel reinforcing rods hanging down from the cap. Pile 1, Bents 18 and 19 have no connection to the cap. Pile 1, Bent 20 showed no connection to the cap. Pile 9, Bents 22 and 21 was observed to have a shattered core. Pile 1, Bent 21 was missing. Photographs 11 through 16 show conditions found at Pier 20. A total of 50 piles were inspected according to Level II requirements. No piles exhibited damage below the waterline. A tabulated summary of inspection observations appears in the Appendix (pages A-13, A-14 and A-24).

4.5.3 Structural Condition Assessment

Pier 20 is in overall good condition. This pier was impacted recently by collision of a ship with the pier deck at the outboard end of the pier. The pier shows no signs of critical pile damage that could be associated with this accident. The critically damaged piles appear to have been damaged either by direct impact to the piles or by deterioration due to exposure to the elements.



NOTES:

1. 2 INDICATES PILE IDENTIFICATION NUMBER
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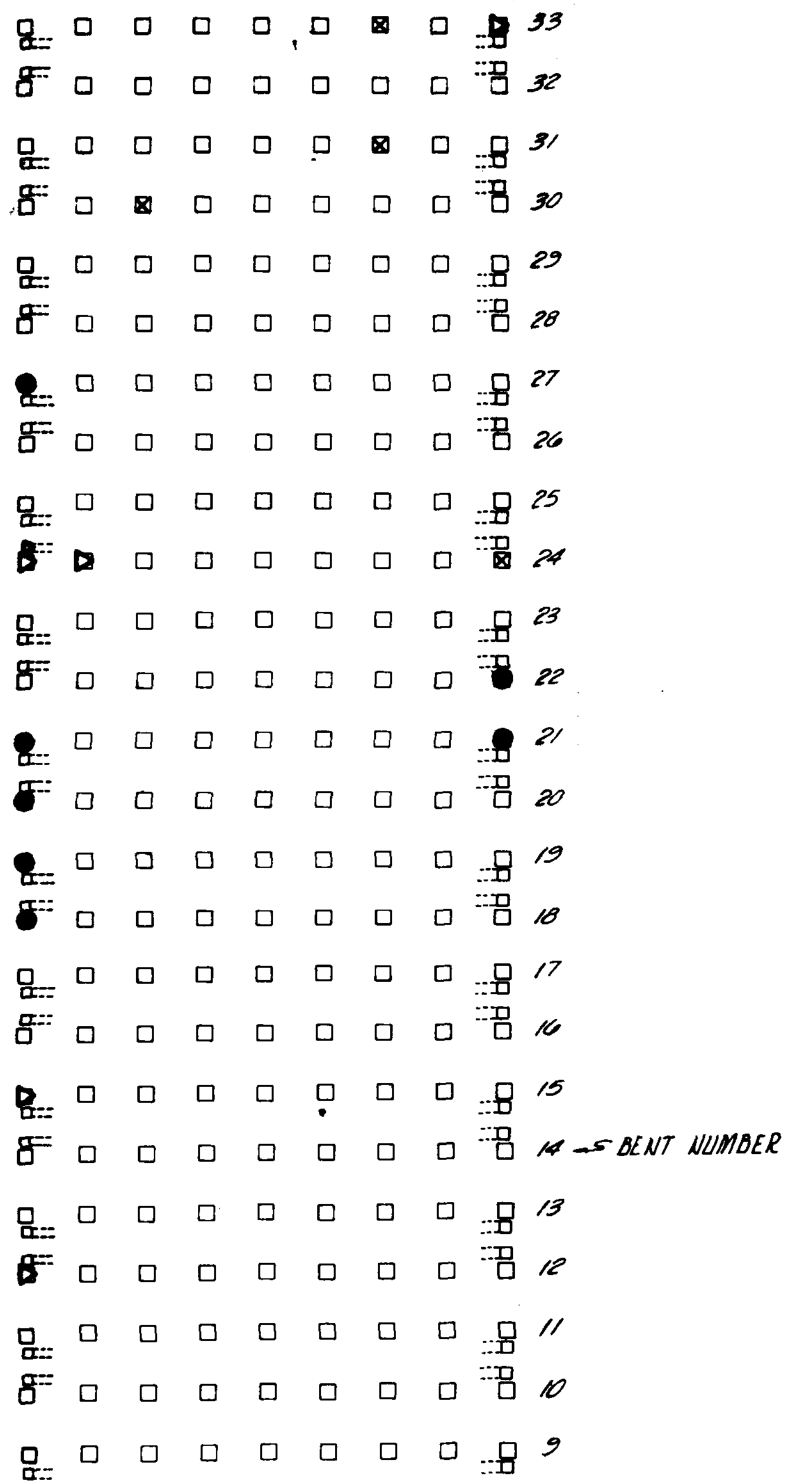
TYPICAL CROSS SECTION THRU PIER 20

FIGURE 25



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PIER LENGTH : 1,451 FT.
PIER WIDTH : 50 FT.
BENT SPACING : 15 FT.

GRAPHIC KEY (N.T.S.)

		Code
□	= GOOD CONDITIONS W/NO APPARENT PROBLEMS	CQ
⊠	= HAIRLINE CRACKS	C1
■	= FAILURE CRACKS	C2
◬	= SPALLED CONCRETE ON SURFACE	C3
○	= DEEPLY SPALLED CONCRETE	C4
●	= FAILED PILE (NO APPARANT BEARING CAPACITY)	C5

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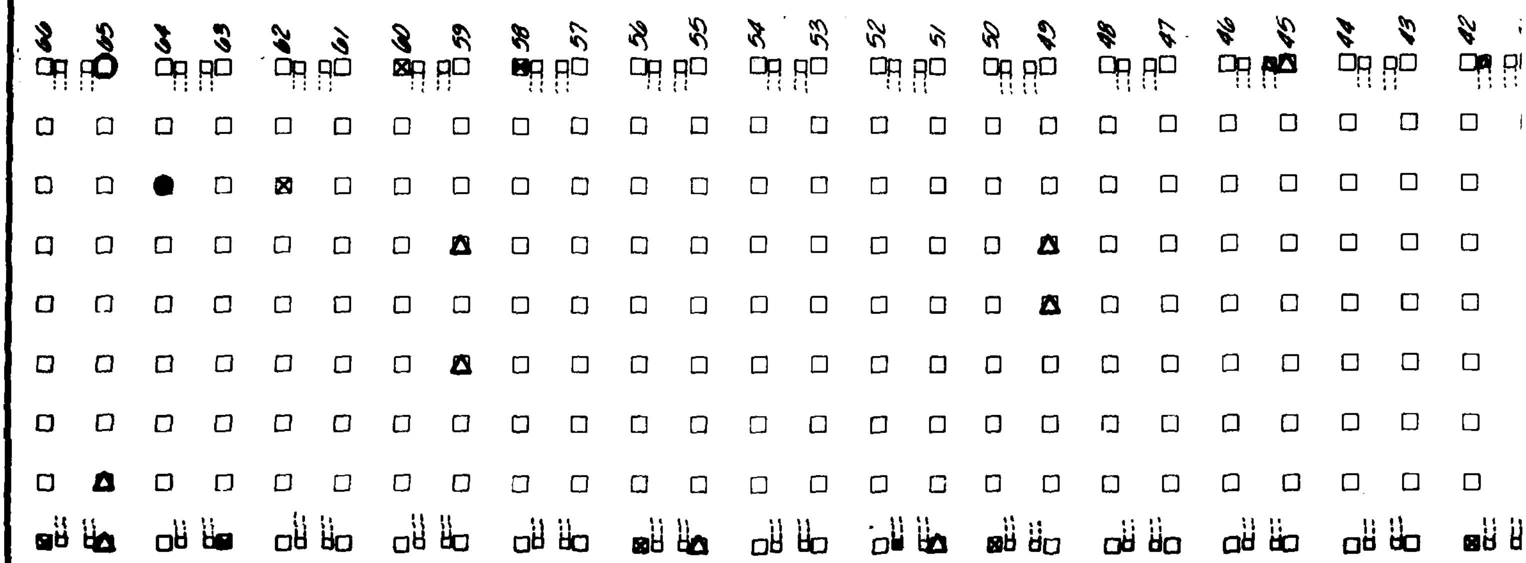
NAVAL STATION NORFOLK, VIRGINIA

PIER 20 PLAN

FIGURE 26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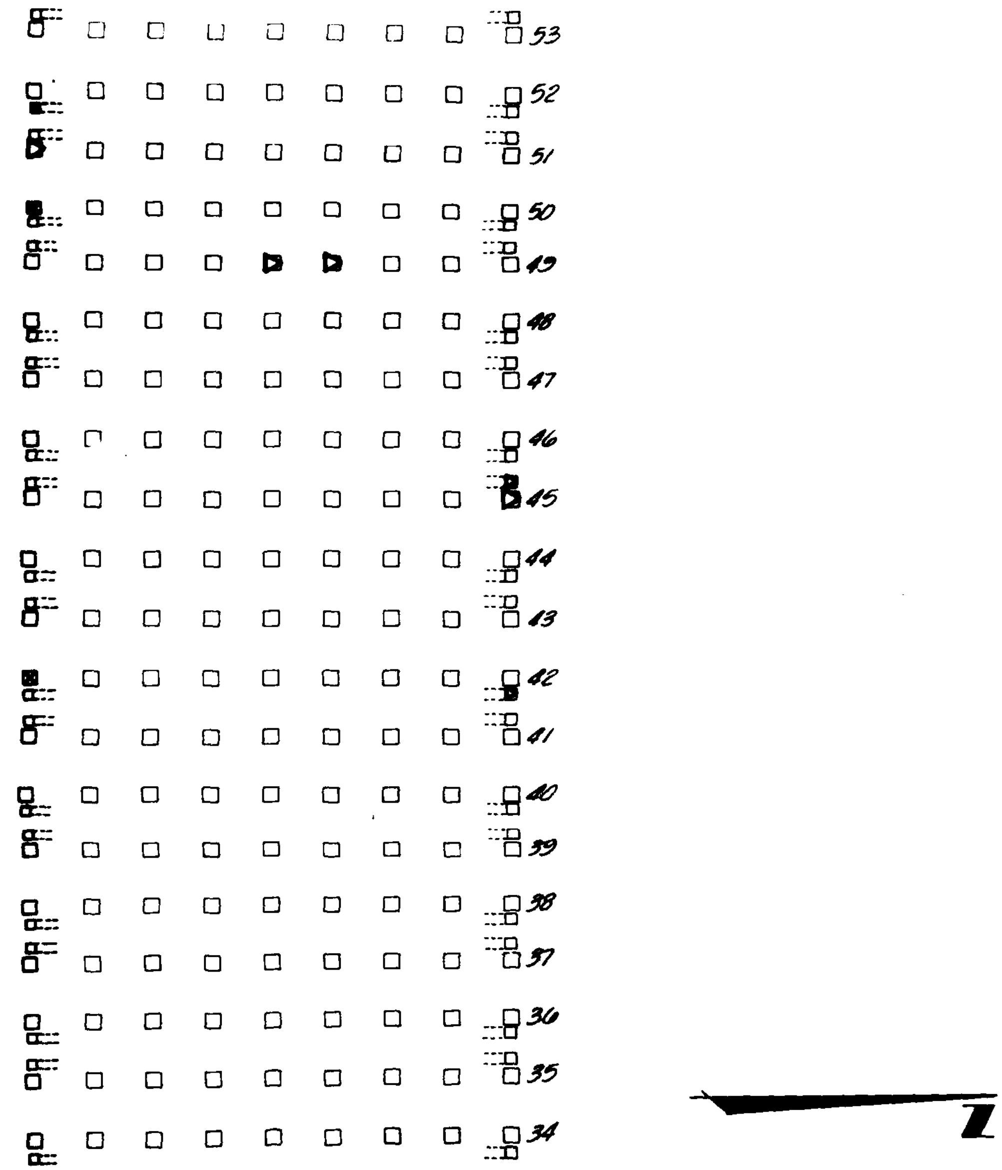

GRAPHIC KEY (N.T.S.)

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- ⊠ = HAIRLINE CRACKS
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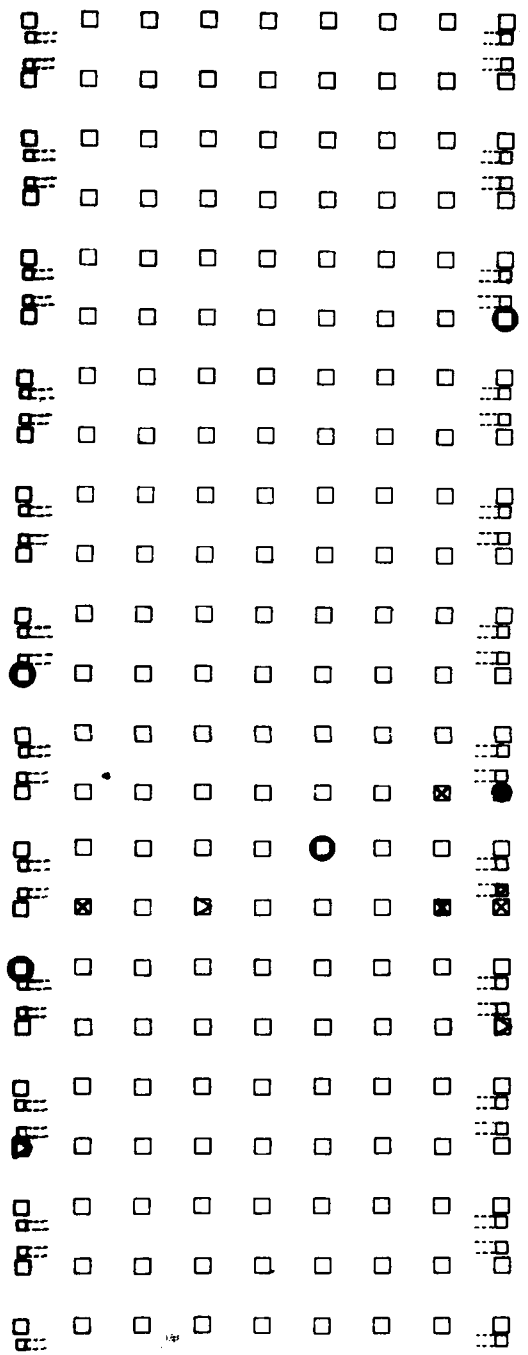
NAVAL STATION NORFOLK, VIRGINIA

PIER 20 PLAN

FIGURE 27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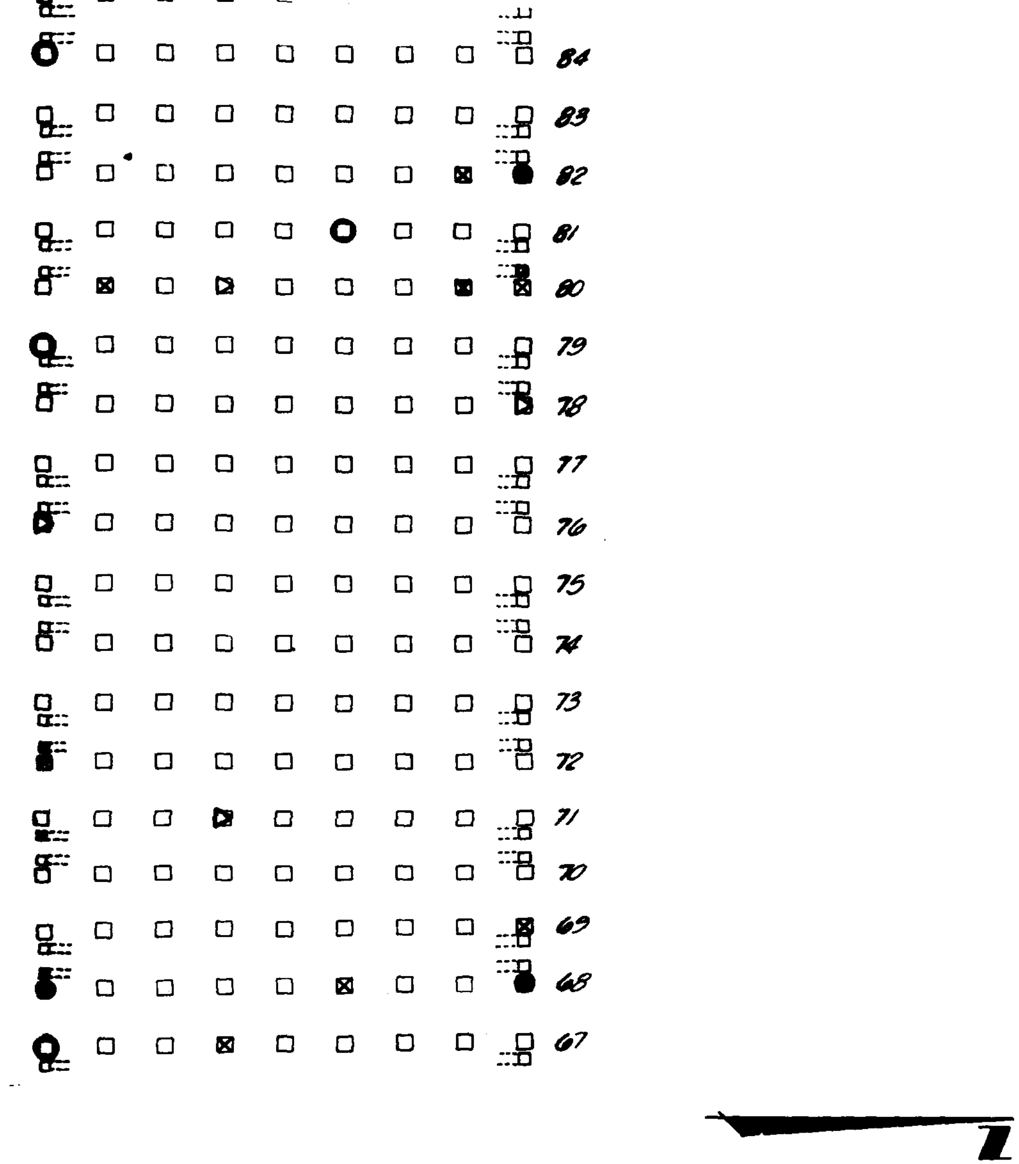

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- ■ = FAILURE CRACKS
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- ○ = DEEPLY SPALLED CONCRETE
- ● = FAILED PILE (NO APPARANT BEARING CAPACITY)

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PIER 20 PLAN

FIGURE 28

Photo No. 11
Pier 20 - Undisturbed marine growth on pile 15 feet below surface (Bent 90).

Photo No. 12
Pier 20 - Pile with portion of face cleaned of marine growth; 15 feet below surface (Bent 90).

Photo No. 13
Pier 20 - Utility pipe supported under pile cap (typical).

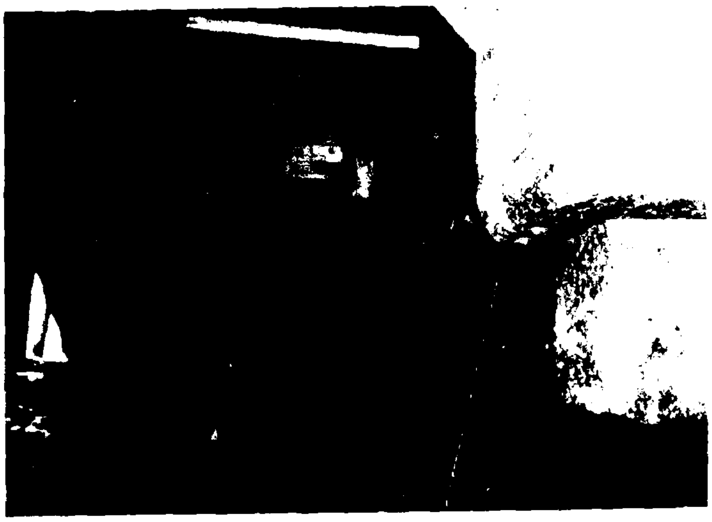


Photo No. 11
Pier 20 - View looking inboard between third and fourth piles from north side of pier. Note good condition of pile in foreground.

Photo No. 15
Pier 20 - A failed pile rated C-5. This pile exhibits heavily spalled concrete with exposed and heavily corroded reinforcing steel (Bent 82).

Photo No. 16
Pier 20 - Spalled concrete with rust stains on exterior vertical pile at center of photo (Bent 79).

4.5.4 Recommendations

All piles exhibiting minor damage, such as cracks and light spalling, should be sealed so as to prevent salt water from penetrating to the reinforcing steel causing corrosion and accelerated deterioration of the pile. The seal should be made with an epoxy grout which can penetrate and seal the hairline and small failure cracks. Of the piles that have deeply spalled concrete or are failed, the greatest degree of damage is in the area of the pile cap. These piles should be repaired by chipping away concrete exposing the reinforcing steel, sand blasting rusted reinforcing steel, and reconstruction of the damaged section by pouring a collar with additional steel reinforcement as required.

One (1) pile was completely missing (see Appendix). This pile should be replaced. Pile replacement requires removal of a section of the pier deck and pile cap for placement and driving of the new pile. The deck and pile cap would be restored following installation of the new pile. The estimated cost of all repairs to Pier 20 is $14,650.

With completion of the above-cited repairs, the expected life of the piles is 30 years. Without these repairs, the expected life of the piles is five (5) to ten (10) years. If repairs are not soon undertaken, the cost and extent of the needed repairs is expected to increase as further deterioration occurs.

The entire pier should be inspected at least once every six (6) years. The pier should also be inspected following any ship-pier collisions to assess damage, if any, to the pier. Once every two (2) years, a cursory inspection by Activity personnel should be performed by boat at low tide to determine any extensive damage to exterior piles which are most susceptible to damage.

4.6 Pier Number 21

4.6.1 Description

Pier 21 is a 1,405 foot long by 50 foot wide reinforced concrete structure, supported by approximately 990 reinforced concrete piles. This pier is located to the immediate north of Pier 20. Figure 10 shows the location of Pier 21 on base. The pier was constructed in 1944. The pier is similar in construction to Pier 20. Each bent has nine (9) vertical piles and two (2) batter piles. Figure 29 shows a typical bent for Pier 21. All of the piles supporting Pier 21 were inspected.

4.6.2 Observed Inspection Condition

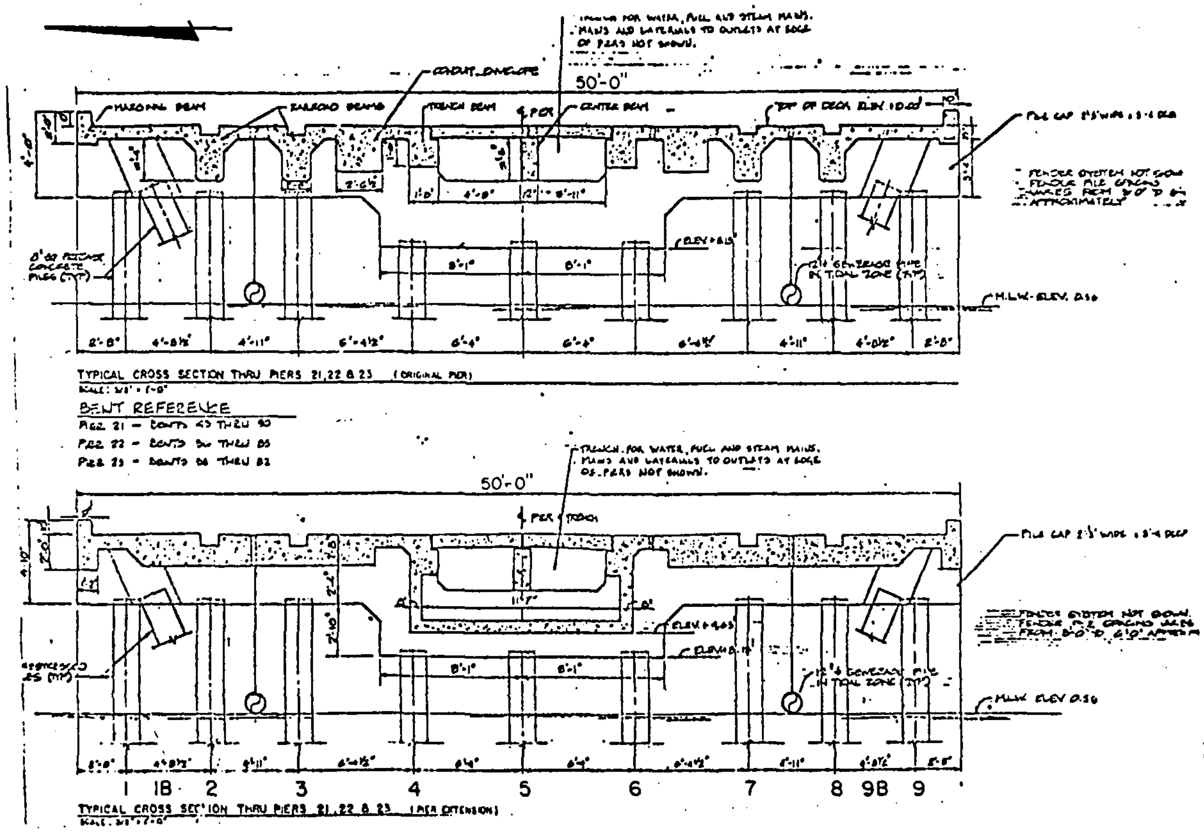
Pier 21 is in overall good condition. A total of nine (9) percent of the piles (93 piles) were found to have some degree of damage ranging from hairline cracks, to completely failed piles offering no support to the pier structure. A total of two (2) percent (20 piles) were found to be in the failed condition. Pile 9, Bent 72 was missing to two (2) feet below the waterline. Pile 9, Bent 56 had four (4) feet of core missing starting at three (3) feet below the cap. Twelve (12) piles were missing entirely. Four (4) piles were found on Level II inspections to have damage below the tidal zone; all such damage was minor spalling or hairline cracks. Figures 30, 31 and 32 show the general pile plan of the pier and identifies the damaged piles. Photographs 11 through 16 of Pier 20 typify conditions observed at Pier 21. A tabulated summary of inspection observations appears in the Appendix (pages A-15 through A-17 and A-25).

4.6.3 Structural Condition Assessment

Pier 21 is in overall good condition. The damaged piles appear to have been damaged either by direct impact to the piles, or by deterioration due to exposure to the elements.

4.6.4 Recommendations

All piles exhibiting minor damage, such as cracks and light spalling, should be sealed so as to prevent salt water from penetrating to the reinforcing steel causing corrosion and accelerated deterioration of the pile. The seal should be made with epoxy grout which can penetrate and seal the hairline and small failure cracks. Of the piles that have deeply spalled concrete or are failed, the greatest degree of damage is in the area of the pile cap. These piles



NOTES:

1. 5 INDICATES PILE IDENTIFICATION NUMBER
2. FROM GOVERNMENT FURNISHED INFORMATION

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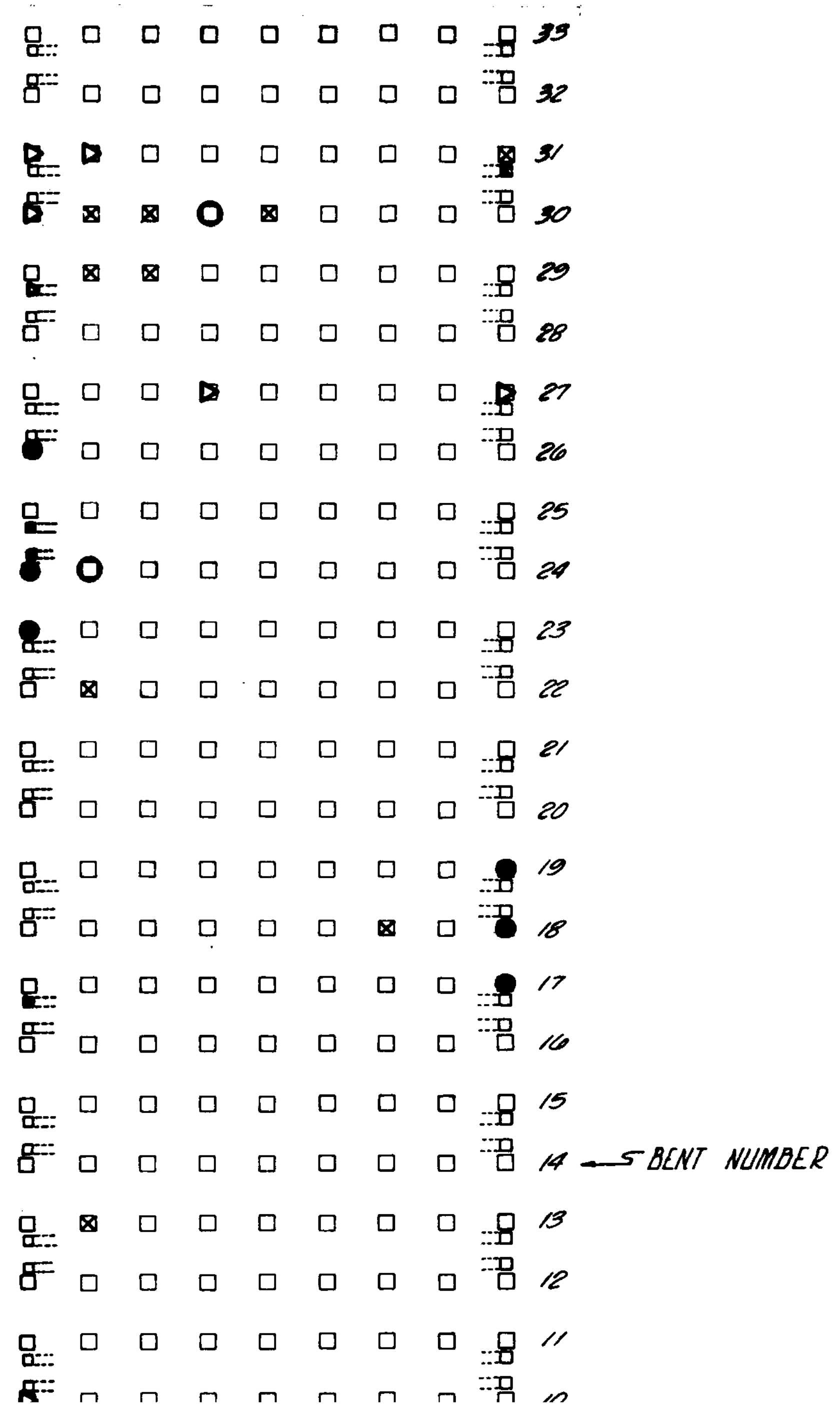
TYPICAL
CROSS SECTION
THRU PIER 21

FIGURE
29



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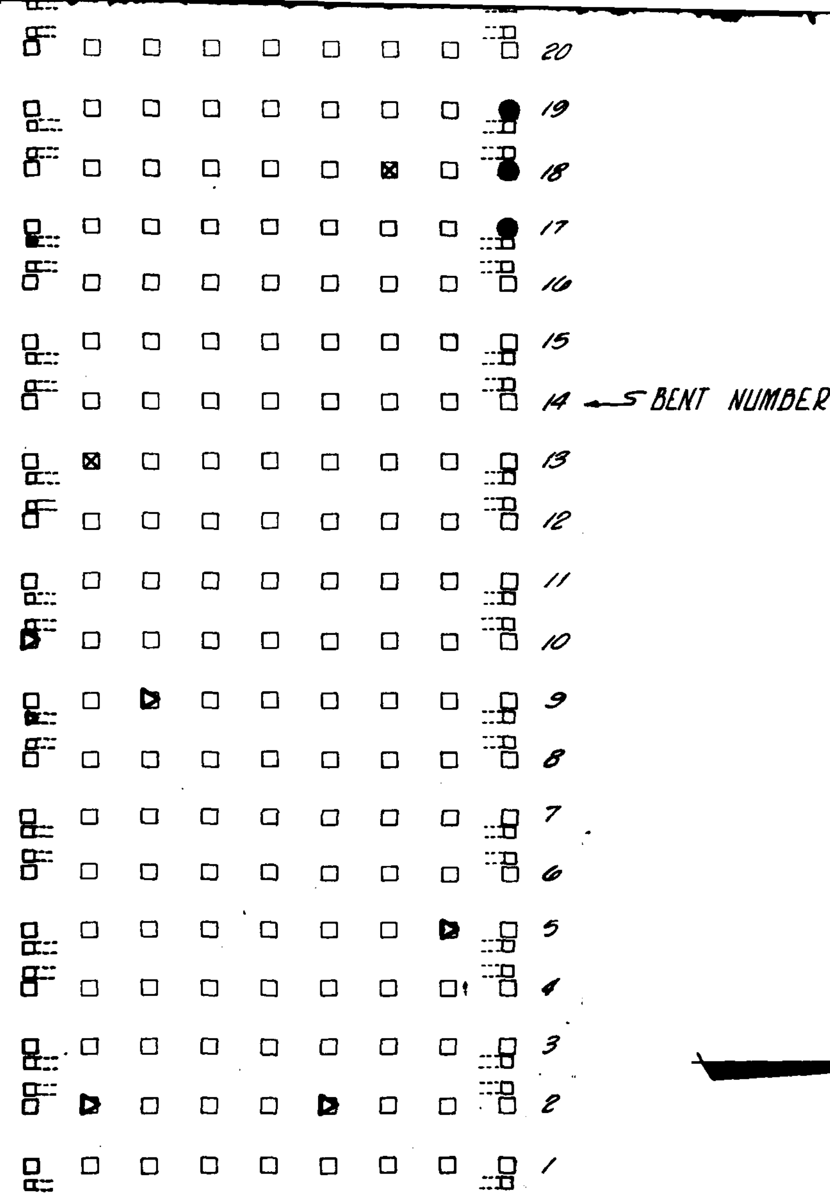

PIER LENGTH: 1,405 FT.
PIER WIDTH: 50 FT.
BENT SPACING: 15 FT.

GRAPHIC KEY (N.T.S.)

Symbol	Description	Code
□	= GOOD CONDITIONS W/NO APPARENT PROBLEMS	C0
⊠	= HAIRLINE CRACKS	C1
■	= FAILURE CRACKS	C2
△	= SPALLED CONCRETE ON SURFACE	C3
○	= DEEPLY SPALLED CONCRETE	C4
●	= FAILED PILE (NO APPARANT BEARING CAPACITY)	C5

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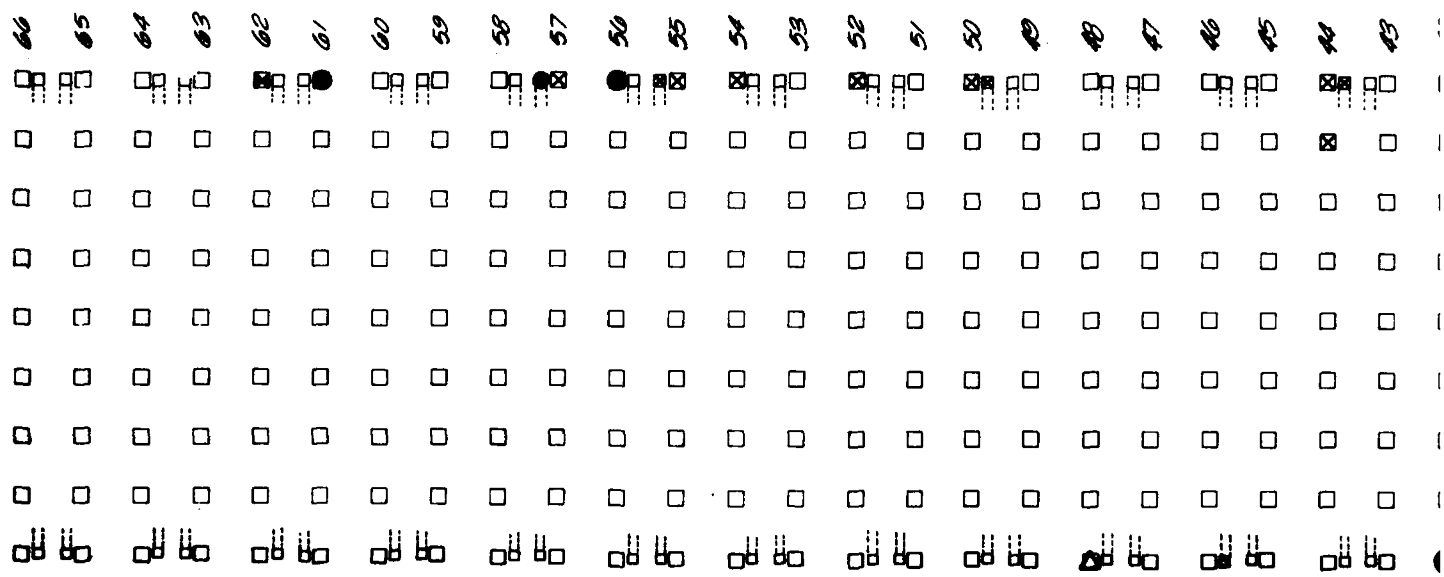
WASHINGTON, D.C.

NAVAL STATION NORFOLK, VIRGINIA

PIER 21 PLAN

FIGURE 30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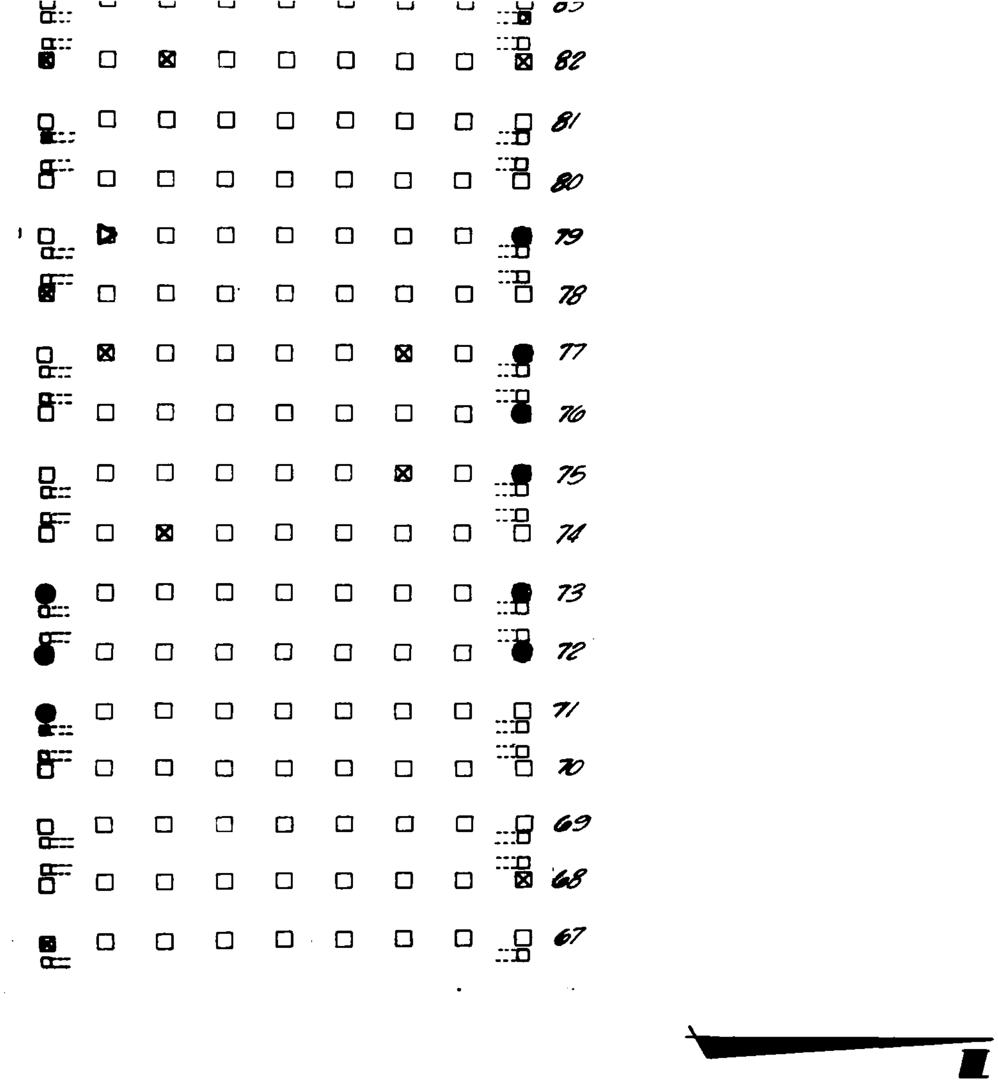

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PIER 21 PLAN

FIGURE 32

should be repaired by chipping away concrete, exposing the reinforcing steel, sand blasting rusted reinforcing steel, and reconstruction of the damaged section by pouring a collar with additional steel reinforcement as required. Some piles were comletely missing (see Appendix); these piles must be replaced. Pile replacement requires removal of the pier deck and pile cap for placement and driving of the new pile. The deck and pile cap must be restored following installation of the new pile. The estimated cost of all repairs to Pier 21 is $45,525.

With completion of the above-cited repairs, the expected life of the piles is 20 years. Without these repairs, the expected life of the piles is three (3) to eight (8) years. If repairs are not soon undertaken, the cost and extent of the needed repairs is expected to increase as further deterioration occurs.

The entire pier should be inspected at least once every six (6) years. The pier should also be inspected following any ship-pier collisions to assess damage, if any, to the pier. Once every two (2) years, a cursory inspection by Activity personnel should be performed by boat at low tide to determine any extensive damage to exterior piles which are most susceptible to damage.

4.7 Bulkhead Number CEP-111

4.7.1 Description

The 1,183 foot Bulkhead CEP-111 is located at the south end of the Naval facility, and east of Pier 20. Figure 10 shows the location of Bulkhead CEP-111 on base. The bulkhead (quaywall) is composed of a cantilevered upper section to retain compacted fill over a pile and concrete sheet pile supported cap. The concrete sheet pile comprises the primary exposed faces. Figure 33 shows typical cross-sections of the bulkhead. Prior to inspection, stations were established every 50 feet along the bulkhead with station zero (0) at the west end of the bulkhead. Damaged fender systems and barges obstructed diver passage in some areas. The total inspection of this bulkhead was enhanced by water visibility (six (6) to eight (8) feet horizontal) that had not been experienced previously at this Naval activity.

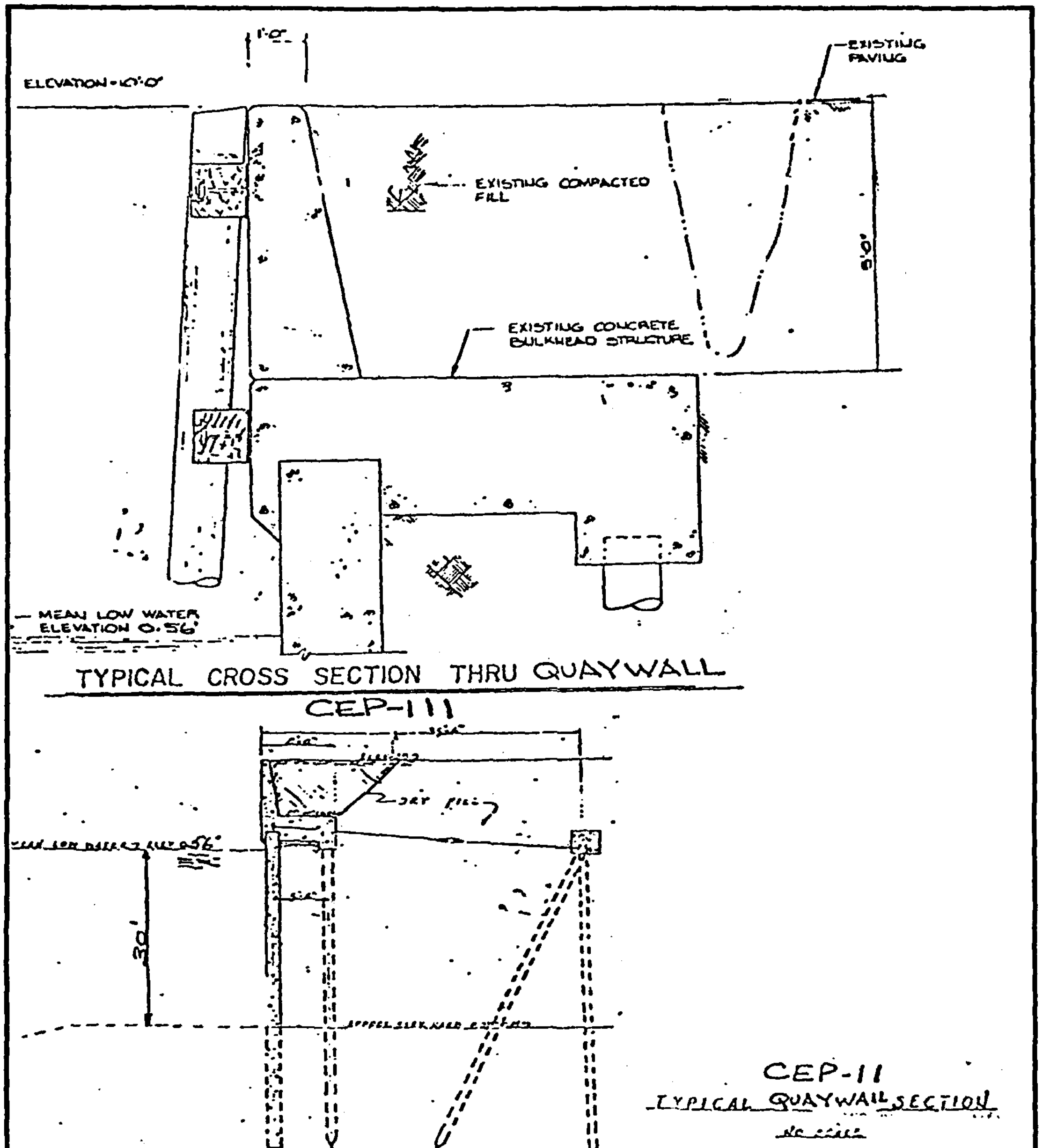
4.7.2 Observed Inspection Condition

The upper portion (cantilever section) of the quaywall has extensive damage in many areas. This appears to be the result of direct impact. Local personnel noted that the wall was recently back-filled where grades subsided following periods of rain.

The Level II underwater inspection revealed the only significant defects to occur at stations 5+20 and 9+20 where heavy spalling was observed at 15 to 20 feet below the water line. This spalling occurred along the joints between the concrete sheet piles. At station 7+20, hairline cracks were found mid-depth between the surface and mudline. These defects were found in the area of maximum moment in the sheet piles. Details of inspection observations are shown in Figure 34. The Appendix (pages A26 through A-28) contains a summary of observations. Photographs 17 through 21 document conditions observed.

4.7.3 Structural Condition Assessment

In general, the bulkhead was found to be in good condition below the water line and fair condition above the water line and along the cap structure. The location of defects in the area of maximum moment indicates that the wall has been overloaded in some regions. The concrete sheet pile joints appear to be leaking.



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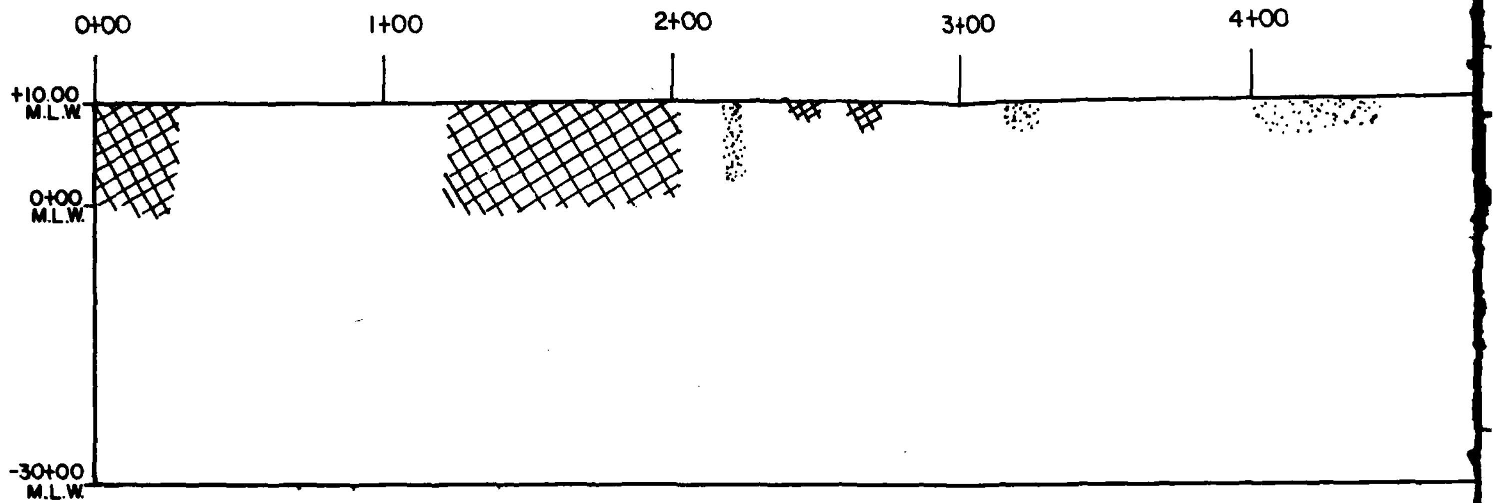
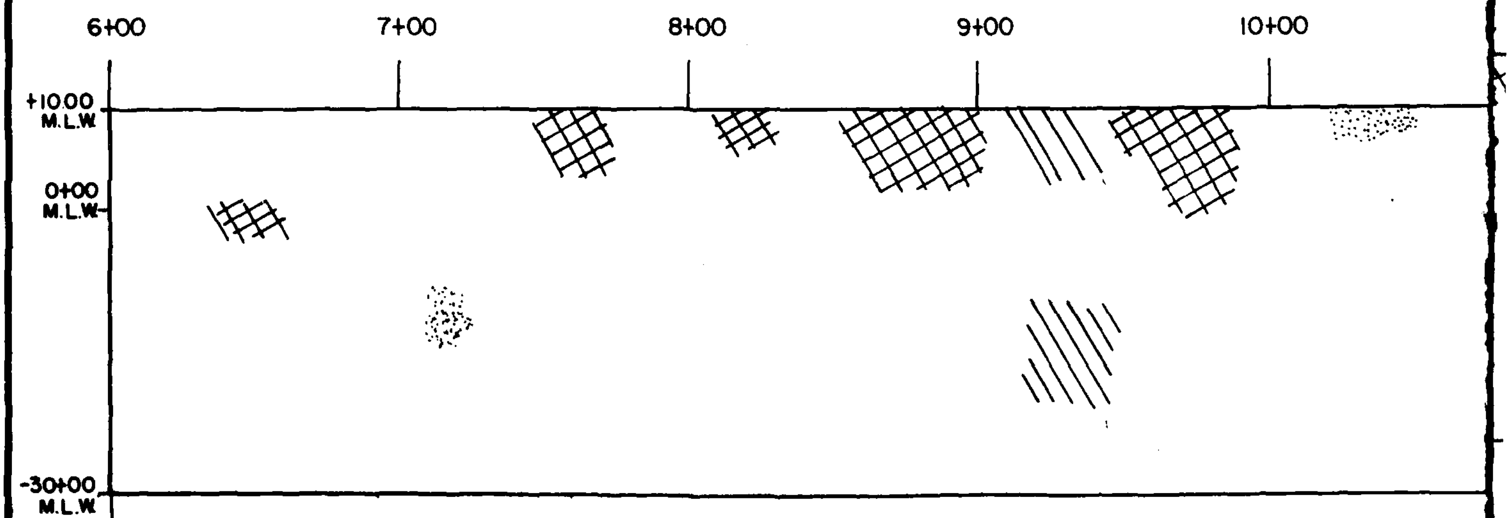


SECTION LOOKING NORTH

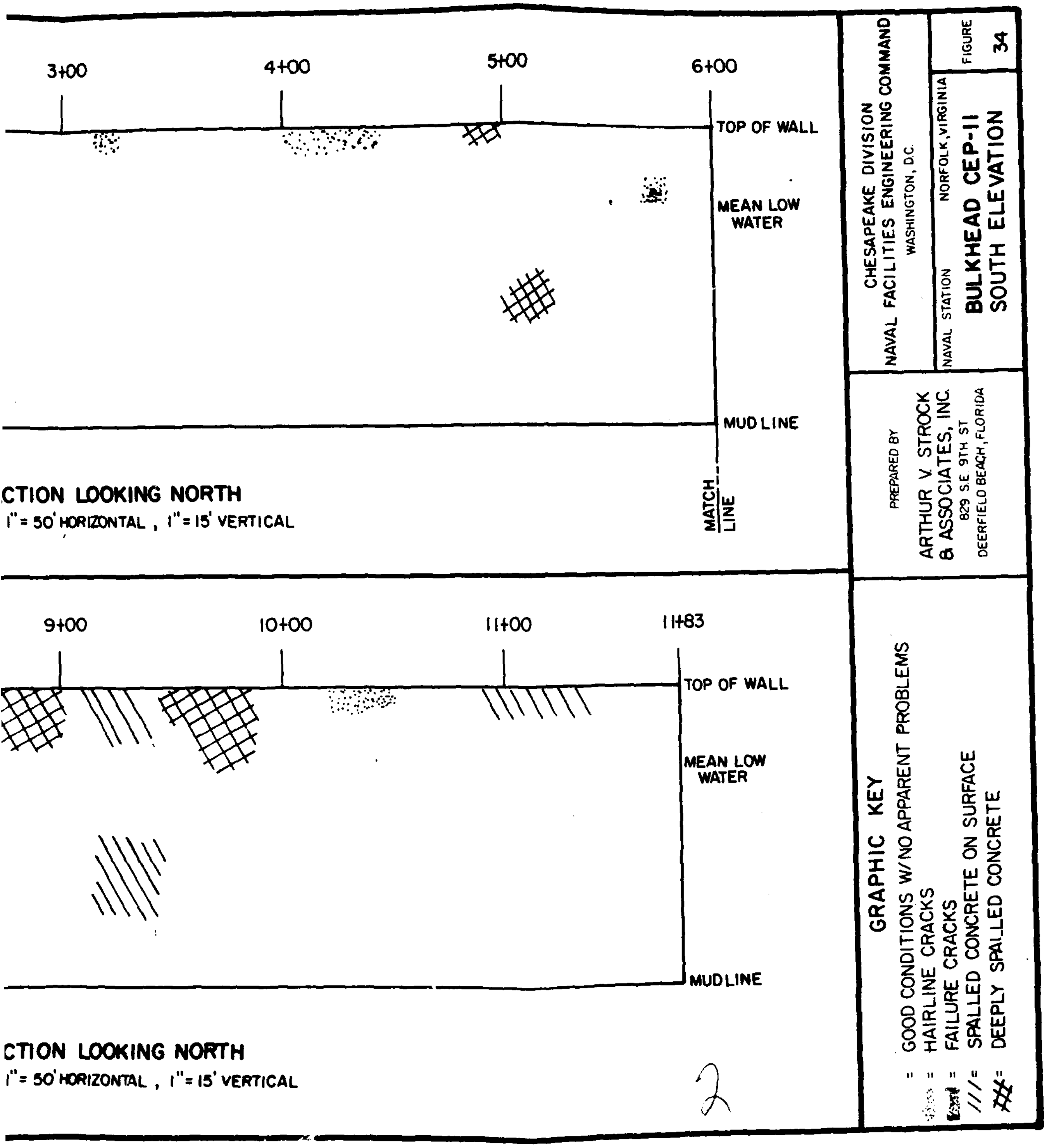
SCALE : 1" = 50' HORIZONTAL , 1" = 15' VERTICAL



MATCH LINE

SECTION LOOKING NORTH

SCALE : 1" = 50' HORIZONTAL , 1" = 15' VERTICAL



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10+00
11+00
11+83
TOP OF WALL
MEAN LOW WATER
MUD LINE
CTION LOOKING NORTH
1" = 50' HORIZONTAL , 1" = 15' VERTICAL
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CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.
NAVAL STATION NORFOLK, VIRGINIA
BULKHEAD CEP-11
SOUTH ELEVATION
FIGURE
34
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DEERFIELD BEACH, FLORIDA
GRAPHIC KEY
= GOOD CONDITIONS W/NO APPARENT PROBLEMS
= HAIRLINE CRACKS
= FAILURE CRACKS
/// = SPALLED CONCRETE ON SURFACE
= DEEPLY SPALLED CONCRETE

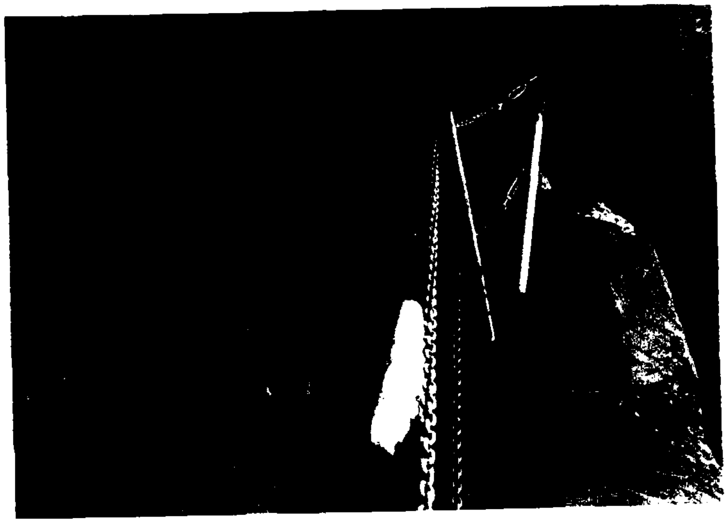

Photo No. 17
Bulkhead CEP-111 - Damage at western end; looking south (Station 0+00).

Photo No. 18
Bulkhead CEP-111 - Photo shows section of bulkhead with damage to cap in foreground (Station 2+50).

AD-A167 861 UNDERWATER FACILITIES INSPECTIONS AND ASSESSMENTS AT NAVAL STATION NORFOL..(U) STOCK (ARTHUR V) AND ASSOCIATES INC DEERFIELD BEACH FL SEP 81 2/2

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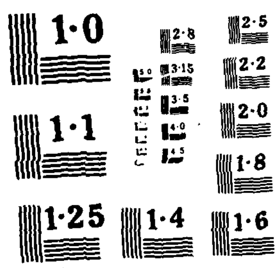
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Photo No. 19
Bulkhead CEP-111 - Badly spalled and cracked upper section (Station 2+65).

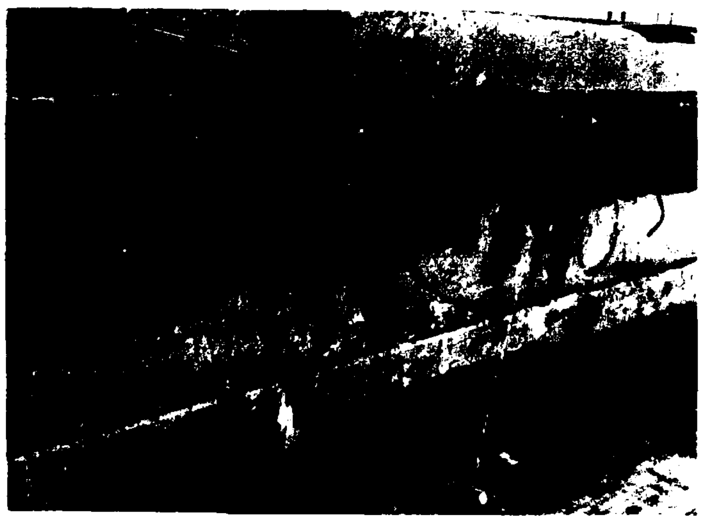


Photo No. 20
Bulkhead CEP-111 - Failure crack in upper section (typical).

Photo No. 21
Eastern end of Bulkhead CEP-111.

4.7.4 Recommendations

The damaged sheet pile joints should be sealed and the damaged sections above the water should be repaired. The sheet pile joints should be sealed with a quick setting epoxy grout between stations 5+00 and 10+00. The cantilever section of the bulkhead should be removed and replaced throughtout those areas with failed or spalled concrete (350 feet total). The estimated cost for these repairs is $40,000.

With completion of the above-cited repairs, the expected life of the bulkhead is 15 years. Without these repairs, the expected life is two (2) to seven (7) years. If repairs are not soon undertaken, the cost and extent of the needed repairs is expected to increase as further deterioration occurs.

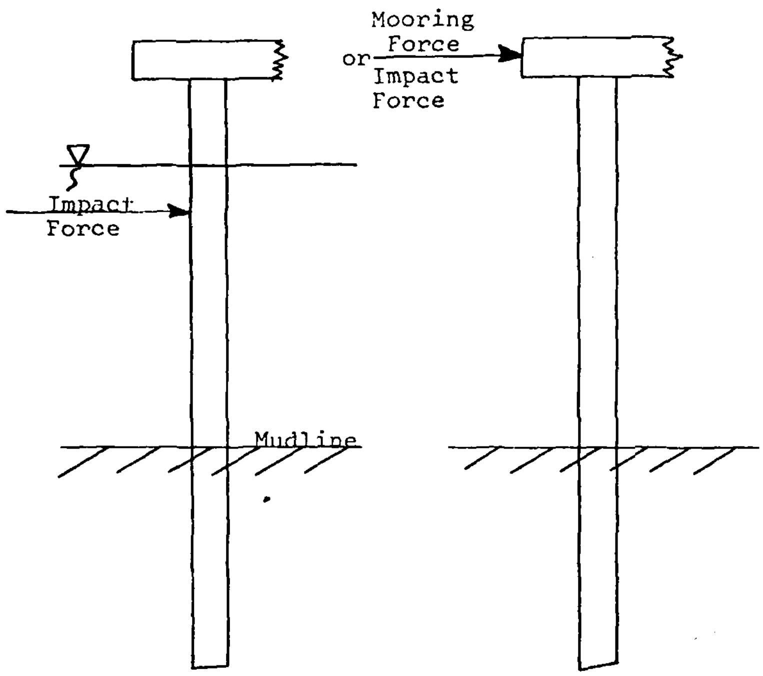
If repairs are performed as prescribed, the bulkhead can then be scheduled for periodic inspections once every six (6) years. The bulkhead should also be inspected following any ship-bulkhead collision to assess damage, if any, to the bulkhead. Once every two (2) years, a cursory inspection by Activity personnel should be performed at low tide to identify maintenance requirements and any damage to the bulkhead.

APPENDIX

PIER PILING - STRUCTURAL ANALYSIS

The primary source of bending moments in piling is due to a direct impact to the pile or an impact to the pier - pile cap girder with a resulting transfer of load to the pile.

These conditions are illustrated below:

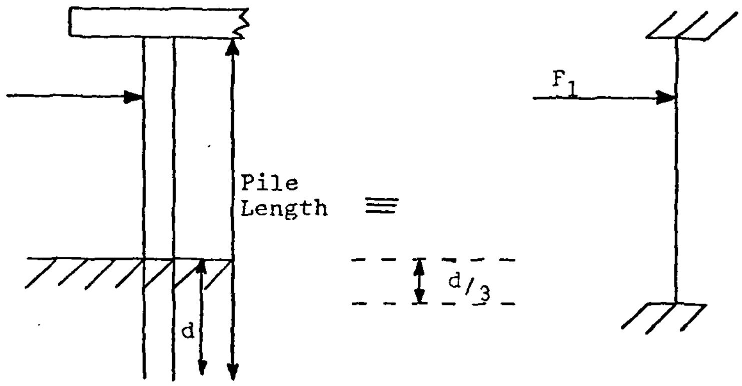


CASE 1
DIRECT IMPACT

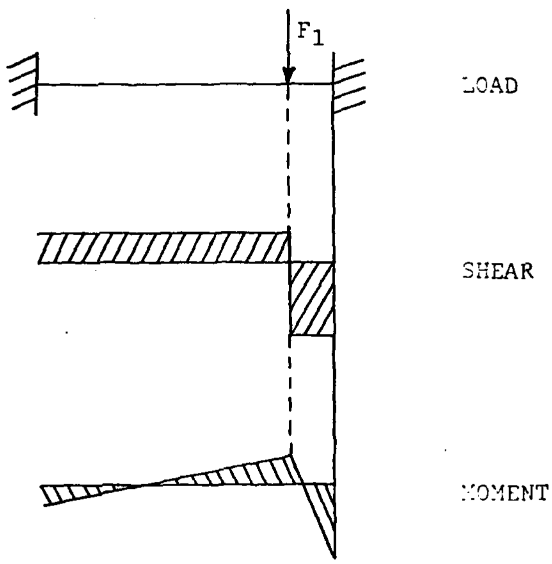
CASE 2
"TRANSFERRED" LOAD

Case 1: Direct Impact

The pile cap may be considered rigid in comparison to a single pile. Similarly the embedded end of the pile may be considered fixed as the "soil" is significantly more rigid than the pile (Ref: Chellis, Pile Foundations). This case is then approximated by the condition illustrated below:



The resulting shear and moment diagrams are as follows:



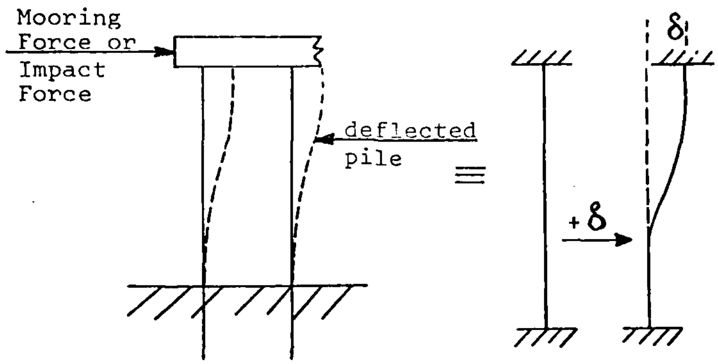
Ref:
Eshbach, 1975
page 520

An impact force may be expected to occur near the waterline due to the possible means of such an impact. This may occur by ramming of a tender vessel or camel into the pile.

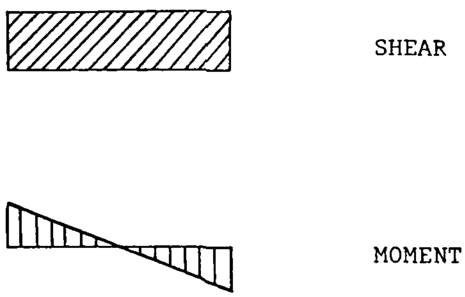
Note that the moment is at a maximum at the cap or at the point of impact which is expected to be near the waterline.

Case 2: Mooring Forces

Again the pile cap may be considered rigid in comparison to a single pile. The Mooring Forces are transferred to the pile via a forced deflection as shown below:



The resulting shear and moments are as given below:



Again as in Case 1, the maximum moment is at the cap and at the mudline.

COST ESTIMATES

Repair	Coded Condition	Estimated Cost
A. Patch w/grout	C1, C2, C3	$ 25/pile
B. Chip away concrete, replace steel as needed, pour collar	C4, C5	$ 650/pile
C. Remove deck, drive new pile, repour deck	C5, pile missing	$3,000/pile

Pier	Repair A (#piles)	Repair B (#piles)	Repair C (#piles)	Total Estimated Repair Cost
20	50	16	1	$ 14,650
21	69	12	12	45,525
5	20	3	0	2,450
7	109	9	0	8,575
12	92	9	1	11,150

Bulkhead Repair

Remove and replace damaged upper sections	$ 35,000
Seal sheet pile joints	5,000
Total	$ 40,000

TABULATED SUMMARY OF OBSERVATIONS
LEVEL I INSPECTION

PIER #5

Bent	Pile	Condition	
Number	Number	Concrete	Steel
24	13	C2	
24	11	C3	S1
25	12	C1	
38	12B	C1	
40	1	C2	
45	7	C2	
45	8	C2	
46	8	C2	
58	2	C2	
61	13	C1	
74	12B	C2	
78	5	C3	
83	5	C2	
86	1	C2	
87	3	C2	
87	1	C4	
88	1	C5	
89	5	C0	S1
89	12	C0	S1
89	12B	C0	S1
91	11	C3	
93	4	C0	S1
93	5	C0	S1
94	2B	C0	S1
99	1	C3	
105	12B	C0	S1
106	2B	C0	S1
106	7	C1	
109	6	C0	S1
109	9	C0	S1
109	12B	C0	S1
110	6	C0	S1
111	6	C2	
111	11	C0	S1
113	6	C0	S1
113	7	C1	S1
114	7	C1	S1

TABULATED SUMMARY OF OBSERVATIONS
LEVEL I INSPECTION

PIER #7

Bent Number	Pile Number	Concrete	Condition Steel
1	1	C3	
1	2	C3	
1	3	C3	
1	4	C3	
1	13	C4	
3	2	C1	
3	2B	C1	
6	2	C1	
6	2B	C1	
6	3	C1	
6	4	C1	
6	5	C1	
6	6	C1	
6	12	C1	
6	12B	C1	
6	13	C1	
10	5	C3	
11	12B	C3	
12	12B	C1	
12	13	C1	
13	2B	C2	
14	4	C3	
14	10	C1	
15	12B	C3	
16	5	C1	
16	9	C1	
17	2B	C2	
18	2	C1	
18	2B	C1	
19	11	C2	
19	13	C2	
20	10	C1	
22	8	C3	
28	10	C1	
28	13	C1	
29	13	C5	
31	10	C3	
33	12B	C3	
35	12B	C1	
35	13	C3	
36	2B	C1	
36	12	C1	

TABULATED SUMMARY OF OBSERVATIONS
LEVEL I INSPECTION

PIER #7
(Continued)

Bent Number	Pile Number	Condition Concrete	Condition Steel
36	12B	C1	
37	8	C4	
39	13	C3	
40	2	C1	
40	2B	C1	
40	10	C1	
40	11	C1	
40	12	C1	
40	12B	C1	
40	13	C1	
41	12	C1	
41	12B	C1	
41	13	C0	S1
42	3	C1	
42	10	C1	
46	12B	C1	
50	12B	C2	S1
52	10	C1	S1
52	12	C1	S1
54	13	C2	
55	5	C3	
55	12B	C3	
55	13	C4	
56	2B	C1	
56	10	C1	
56	12B	C2	S1
56	13	C2	
58	1	C1	
58	10	C1	
60	1	C1	S1
60	13	C1	
62	3	C3	
62	13	C2	
63	13	C2	
64	2B	C3	
64	13	C1	S1
65	10	C4	
66	2B	C2	
67	1	C1	
67	2	C1	
67	2B	C1	
67	3	C1	

TABULATED SUMMARY OF OBSERVATIONS
LEVEL I INSPECTION

PIER #7
(Continued)

Bent Number	Pile Number	Condition Concrete	Condition Steel
67	9	C1	
67	10	C1	
67	12B	C2	
67	13	C2	
68	2	C0	S1
68	11	C1	
70	12B	C2	
71	10	C1	
71	11	C1	
71	12	C2	
72	1	C1	
72	2B	C3	
72	11	C3	
72	12B	C2	S1
74	2B	C1	
74	13	C3	
79	6	C3	
82	13	C2	S1
83	7	C3	
87	7	C3	
87	11	C3	
88	1	C4	
88	12B	C0	S1
89	3	C1	
89	4	C1	
89	9	C1	
91	12B	C5	
92	1	C3	S1
93	4	C3	
95	3	C1	
95	10	C1	
97	2B	C4	S4
98	2B	C4	S4
100	13	C0	S1
105	2B	C1	S1
106	2B	C1	S1
107	9	C1	
109	5	C0	S1
110	9	C0	S1
115	13	C3	

TABULATED SUMMARY OF OBSERVATIONS
LEVEL I INSPECTION

PIER #12

Bent Number	Pile Number	Concrete	Condition Steel
7	3	C1	
8	8	C1	
8	10	C3	
10	13	C1	
10	21	C1	
10	21B	C1	
11	1	C2	
12	3B	C1	
12	5	C1	S1
12	6	C1	
13	22	C3	
14	21	C1	
15	23	C3	
17	22	C3	
18	21	C3	
21	3	C3	
26	3B	C3	
42	7	C1	
51	1	C4	
52	1	C5	
58	23	C5 (missing)	
60	14	C1	
60	15	C1	
60	21	C1	
61	7	C3	
61	14	C2	
61	21B	C2	
61	23	C3	
64	19	C1	
64	20	C1	
65	5	C1	
65	6	C1	
65	10	C1	
65	13	C1	
66	20	C1	
67	13	C2	
67	16	C2	
67	21B	C2	
68	20	C1	
68	21B	C2	S1
69	1	C5	S4
70	21B	C1	
71	15	C2	

TABULATED SUMMARY OF OBSERVATIONS
LEVEL I INSPECTION

PIER #12
(Continued)

Bent Number	Pile Number	Condition Concrete	Condition Steel
71	19	C2	
71	21B	C2	
72	6	C1	
73	1	C4	S4
73	21B	C2	
74	21B	C1	
75	1	C4	S3
75	7	C2	
75	12	C2	
75	17	C3	
75	21B	C2	
76	9	C1	S1
76	10	C1	S1
76	11	C1	S1
76	18	C0	S1
77	1	C4	S3
77	10	C2	
77	12	C2	
77	20	C0	S2
77	23	C2	S3
78	1	C5	S4
78	23	C1	S1
79	1	C1	
79	2	C2	
79	3	C0	S1
79	3B	C2	
79	4	C1	
80	2	C1	
80	3B	C1	S1
80	4	C1	
80	9	C1	S1
80	10	C3	S2
80	23	C1	
81	8	C2	
81	18	C2	
82	4	C4	
82	20	C1	S1
83	5	C2	
83	11	C2	
83	15	C1	
83	21	C2	
83	22	C2	
83	23	C1	

TABULATED SUMMARY OF OBSERVATIONS
LEVEL I INSPECTION

PIER #12
(Continued)

Bent Number	Pile Number	Condition Concrete	Condition Steel
84	1	C1	
84	2	C1	
84	4	C1	
84	17	C1	
84	23	C1	
85	5	C1	
85	7	C1	
85	17	C2	S2
85	19	C2	
86	2	C1	
87	14	C3	
87	16	C2	S2
87	19	C3	
88	3B	C3	
89	3	C0	S1
89	17	C3	
89	18	C2	
89	20	C3	
89	21	C1	
89	23	C1	
90	17	C4	S2

TABULATED SUMMARY OF OBSERVATIONS
LEVEL I INSPECTION

PIER #20

Bent Number	Pile Number	Condition Concrete	Steel
1	2	C1	S1
1	3	C1	
1	4	C1	
2	9	C3	
3	1	C0	S1
12	1	C3	
15	1	C3	
18	1	C5	
19	1	C5	
20	1	C5	
21	1	C5 (missing)	
21	9	C5	
22	9	C5	
24	1	C3	
24	1B	C3	
24	2	C3	
24	9	C1	
27	1	C5	S4
30	3	C1	
31	7	C1	
33	7	C1	
33	9	C3	
35	9B	C0	S1
42	1	C1	
42	9B	C3	
43	9	C0	S1
44	9	C0	S1
45	9	C3	
45	9B	C3	
48	1	C0	S1
49	5	C3	
49	6	C3	
50	1	C1	S1
51	1	C3	
52	1B	C1	
55	1	C3	
56	1	C1	
58	9	C2	
59	4	C3	S1
59	6	C3	S1
60	9	C1	
62	7	C1	
63	1	C2	

TABULATED SUMMARY OF OBSERVATIONS
LEVEL I INSPECTION

PIER #20
(Continued)

Bent Number	Pile Number	Condition Concrete	Condition Steel
64	7	C5	
65	1	C3	
65	2	C3	
65	9	C4	S4
66	1	C1	
67	1	C4	S1
67	4	C1	
68	1	C5	
68	1B	C2	
68	6	C1	
68	9	C5	
69	9	C1	
71	1B	C2	
71	4	C3	
72	1	C1	
72	1B	C1	
76	1	C3	
76	8	C0	S1
78	1	C0	S3
78	8	C0	S1
78	9	C3	
79	1	C4	S2
80	2	C1	S1
80	4	C3	S1
80	8	C2	S1
80	9B	C3	
80	7	C0	S1
80	9	C1	
81	1	C0	S2
81	6	C4	
81	9	C0	S1
82	8	C1	
82	9	C5	
84	1	C4	S1
90	9	C4	S3

TABULATED SUMMARY OF OBSERVATIONS
LEVEL I INSPECTION

PIER #21

Bent Number	Pile Number	Condition Concrete	Steel
1	9	C3	
2	2	C3	
2	6	C3	
4	2	C0	S3
5	8	C3	
6	3	C0	S1
9	1B	C3	
9	3	C3	
10	1	C3	
13	2	C1	
17	1B	C3	S1
17	9	C5	S4
18	7	C1	
18	9	C5	S4
19	9	C5	S4
21	1B	C0	S1
22	2	C1	S1
23	1	C5	S4
24	1	C5 (missing)	
24	2	C4	
24	1B	C5	
25	1B	C5	S4
26	1	C5	
27	4	C3	
27	9	C3	
29	2	C1	
29	3	C1	
29	1B	C3	
29	7	C0	S1
30	1	C3	
30	1B	C0	S3
30	2	C1	
30	3	C1	
30	4	C4	
30	5	C1	S3
31	1	C3	
31	2	C3	
31	9B	C1	
31	9	C1	
32	1	C0	S3
32	4	C0	S3
34	1	C4	
35	1	C1	S1
35	6	C3	

TABULATED SUMMARY OF OBSERVATIONS
LEVEL I INSPECTION

PIER #21
(Continued)

Bent Number	Pile Number	Condition: Concrete	Condition: Steel
35	9	C3	
36	2	C0	S3
38	1	C1	
38	2	C1	
42	1	C4	
42	2	C0	S1
44	8	C1	
44	9B	C1	
44	9	C1	
46	1B	C3	S1
48	1	C3	
50	9B	C1	S1
50	9	C1	S1
52	9	C1	S1
54	9	C1	
55	9B	C1	
55	9	C1	
56	1B	C0	S1
56	9	C5	
56	9B	C0	S1
57	9	C2	
57	9B	C5 (missing)	
61	9	C5 (missing)	
62	9	C2	
67	1	C1	
67	1B	C0	S1
68	1	C0	S1
68	1B	C0	S1
68	2	C0	S1
68	9	C1	
71	1	C5 (missing)	
71	1B	C1	
71	9	C0	S1
72	1	C5 (missing)	
72	9	C5 (missing)	
73	1	C5 (missing)	
73	9	C5 (missing)	
74	3	C1	
75	7	C1	
75	9	C5 (missing)	
76	9	C5 (missing)	
77	2	C1	

TABULATED SUMMARY OF OBSERVATIONS
LEVEL I INSPECTION

PIER #21
(Continued)

Bent Number	Pile Number	Condition Concrete	Steel
77	7	C1	
77	9	C5 (missing)	
78	1	C1	
79	2	C3	
79	9	C5 (missing)	
81	1B	C1	
82	1	C1	
82	3	C1	
82	9	C1	
83	1B	C0	S1
83	9B	C3	
84	2	C1	
85	2	C1	
85	1B	C1	
85	7	C0	S1
85	9	C1	
87	1	C1	
87	1B	C3	S1
87	7	C1	S1
87	9	C1	
88	9	C1	
89	1	C3	
89	5	C3	
89	7	C1	
90	3	C3	

TABULATED SUMMARY OF OBSERVATIONS
LEVEL II INSPECTION

PIER #5

Bent Number	Pile Number(s)	Condition of Pile
69	12,13	CO
70	1,2	CO
71	13	CO
72	1,2	CO
73	12,13	CO
74	1,2	CO
75	12,13	CO
76	1,2	CO
77	12,13	CO
78	1,2	CO
79	12,13	CO
80	1,2	CO
81	1,2	CO
81	12,13	CO
83	12,13	CO
84	1,2	CO
85	12,13	CO
86	1	C2 1' below waterline C4 10' below waterline
86	2	CO
87	12,13	CO
88	1	C5 at top to 2' below waterline
88	2	CO
89	12,13	CO
90	1,2	CO
91	12,13	CO
92	1,2	CO
93	12,13	CO
94	1,2	CO
95	1,2	CO
95	12,13	CO
97	12,13	CO
98	1	CO
99	12,13	CO
100	1,2	CO
101	12,13	CO
102	1,2	CO
103	1,2	CO
103	12,13	CO
105	12,13	CO

TABULATED SUMMARY OF OBSERVATIONS
LEVEL II INSPECTION

PIER #5
(Continued)

Bent Number	Pile Number(s)	Condition of Pile
106	1,2	CO
107	12,13	CO
108	1,2	CO
109	12,13	CO
110	1,2	CO
111	12,13	CO
112	1,2	CO
113	12,13	CO
114	1,2	CO

TABULATED SUMMARY OF OBSERVATIONS
LEVEL II INSPECTION

PIER #7

Bent Number	Pile Number(s)	Condition of Pile
4	13	CO
10	13	CO
14	13	CO
28	13	CO
29	13	C5 0 - 5' (shattered core) CO 5' to bottom
32	13	CO
34	13	CO w/small corner chip 3'
36	13	CO
38	13	CO
40	12	C1 0 - 5' CO 5' to bottom
42	13	C1 0 - 5' CO 5' to bottom
44	13	CO
46	13	CO
46	13	CO
48	13	CO
50	13	CO
52	13	CO
54	13	CO
56	13	CO
58	13	CO
60	13	CO
62	13	CO
64	13	CO
66	13	CO
70	13	CO
72	13	CO
74	13	C3 0 - 5' C2 5 - 10' CO 10' to bottom
78	13	CO
80	13	CO
82	13	CO
84	13	CO
86	13	CO
88	13	CO 0 - 5' C4 5 - 10' CO 10' to bottom
88	12	CO
90	12,13	CO

TABULATED SUMMARY OF OBSERVATIONS
LEVEL II INSPECTION

PIER #7
(Continued)

Bent Number	Pile Number(s)	Condition of Pile
92	12,13	C3 0 - 10' CO 10' to bottom
94	12,13	CO
98	12,13	CO
99	1	CO
100	12,13	CO
101	1,2	CO
103	12,13	CO
103	1,2	CO
104	12,13	CO
105	1,2	CO
106	12,13	CO
107	1,2	CO
108	12,13	CO
109	1,2	CO
110	12,13	CO
111	1,2	CO
112	12,13	CO
113	1,2	CO
114	12,13	CO
115	1	CO

TABULATED SUMMARY OF OBSERVATIONS
LEVEL II INSPECTION

PIER #12

Bent Number	Pile Number(s)	Condition of Pile
6	23	CO
7	1	CO
8	23	CO
9	1	CO
9	23	CO
10	1	CO
11	23	CO
12	1	CO
13	23	CO
14	1	CO
15	23	CO
16	1	CO
17	23	CO
18	1	CO
19	23	CO
20	1	CO
21	23	CO
23	23	CO
24	1,2	CO
25	23	CO
27	23	CO
28	1,2	CO
28	23	CO
29	23	CO
30	1	CO
31	23	CO
32	1	CO
33	23	CO
34	1	CO
35	23	CO
37	23	CO
38	1	CO
39	23,22	CO
40	1,2	CO
43	23,22	CO
44	1,2	CO
48	1,2	CO
51	1	C4 at top CO below MLW
52	2	CO
51	23,22	CO
52	1	C5 at top CO below MLW
52	2	CO

TABULATED SUMMARY OF OBSERVATIONS
LEVEL II INSPECTION

PIER #12
(Continued)

Bent Number	Pile Number(s)	Condition of Pile
55	23,22	CO
56	1,2	CO
58	22	CO
58	23	C5; pile missing
59	22	CO
59	23	CO
60	1,2	CO
63	23,22	CO
64	1,2	CO
67	23,22	CO
68	1,2	CO
69	1	C5 at top CO below MLW
69	2	CO
71	23,22	CO
73	1	C4 at top CO below MLW
73	2	CO
75	23,22	CO
78	1	C5 at top, no connection C2 at -5'
78	2	CO
79	23,22	CO
82	1,2	CO
83	23,22	CO
86	1,2	CO
87	23,22	CO
89	23	CO
90	1,2	CO
90	5,6	CO
90	9,10	CO
90	13,14	CO
90	17	C4 at top CO below MLW
90	18,19	CO
90	20	CO

TABULATED SUMMARY OF OBSERVATIONS
LEVEL II INSPECTION*

PIER #20

Bent Number	Pile Number(s)	Condition of Pile
4	1	CO*
8	1	
12	1	
16	1	
20	9B	
22	1	
28	1	
31	9	
44	9	
46	1	
48	9	
50	1	
52	8	
54	1	
56	9	
58	1	
62	9	
64	9	
66	1	
68	8	
70	1	
72	9	
74	1	
76	9	
78	1	
80	9	
82	1	
83	1,2	
83	9,9B,8	
87	1,2	
87	9,9B,8	
89	1	
91	1,2	
91	9,9B	
93	1,2	
95	1,1B,2	
95,	9,9B,8	

*Level II underwater inspection of piles listed in this table showed no signs of damage below the waterline. For evaluation of damage above the waterline consult Appendix - "Tabulated Summary of Observations - Level I Inspection - Pier #20."

TABULATED SUMMARY OF OBSERVATIONS
LEVEL II INSPECTION

PIER #21

Bent Number	Pile Number(s)	Condition of Pile
1	9	C3
27	9B	CO
29	9	CO
31	9B	CO
33	9	CO
35	9	C3 0 - 5' CO 5' to bottom
37	9	CO
39	9	C1 0 - 20' CO 20' to bottom
41	9	CO
43	9	CO
45	9	CO
48	1	CO
53	9	C1 0 - 5' CO 5' to bottom
55	1	CO
57	1	CO
57	9B	CO
59	1	CO
63	1	CO
64	9	CO
67	1	CO
69	9	CO
71	9	CO
73	1B	CO
75	8	CO
81	1	CO
81	9B	CO
83	9	CO
85	1	CO
87	1	CO
89	9	CO
90	9	CO

SUMMARY OF OBSERVATIONS

BULKHEAD CEP-111

Station	Remarks
0+00	Sink hole; C4, S4
0+00 - 0+20	C2, C4, S4 at waterline (CO Level II)
0+20 - 0+30	C2 at waterline C4, S1
0+60	Level II CO to bottom
1+20	C4, S4, S1 top to waterline; Level II CO to bottom
1+30 - 1+80	C4, S4 surf to waterline; steel cable showing at waterline; Level II CO below surf to bottom
1+90 - 2+00	Top sheet C4, S4
2+15	C1
2+30	Level II CO to bottom
2+40	C4
2+60	Surf C4, S4, S2
2+60 - 3+20	CO; barge on
3+20	C1
3+30	Level II CO to bottom
3+70	Level II CO to bottom
3+90	Barge on
4+00 - 4+40	C1
4+60	Level II CO to bottom
4+80 - 4+90	C1, C4
5+20	Level II C4 to half
5+70 - 5+80	C1 surface

SUMMARY OF OBSERVATIONS

BULKHEAD CEP -111
(continued)

Station	Remarks
6+10	Level II CO
6+40 - 6+50	Surf C4
7+20	Level II C1 halfway to bottom
7+30 - 8+00	Barge
7+50 - 7+70	Top wall C4
7+70	C4, C1
8+10 - 8+80	C1
8+10	Level II CO to bottom
8+20	Top cap C4
8+60	Top cap S4, C4, C1
8+70	Top cap S4, C4, C1
8+90 - 9+00	Top cap S4, C4, C1
8+90	Level II CO
9+20 - 9+40	C3, S4
9+20	Level II CO
9+20 - 9+50	C3 at seams between stations
9+50	Level II CO
9+50	C4, S4
9+50 - 11+00	Ship
9+90	C4, S4 at top to waterline
10+20 - 10+50	C1 surf; some appear patched
11+00	Level II CO to bottom

SUMMARY OF OBSERVATIONS

BULKHEAD CEP-111
(continued)

Station	Remarks
11+00	C3, S3 surf and top cap
11+20	Level II CO to bottom
11+30 - 11+40	C3 top cap
11+40	Level II CO to bottom
Other notes:	Five (5) foot panels; local personnel remarked that sink hole formation was very gradual and developed during rainy periods; six (6) to eight (8) foot visibility

END

DATE
FILMED

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